On-Line Process Monitoring and Electric Submetering at Six Municipal Wastewater Treatment Plants

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ON-LINE PROCESS MONITORING AND ELECTRIC SUBMETERING AT SIX MUNICIPAL WASTEWATER TREATMENT PLANTS

Final Report

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NOTICE

ABSTRACT

An investigation was made of New York State wastewater treatment plants (WWTPs) to determine if process audit and electrical submetering techniques are an effective method of identifying energy conservation opportunities (ECOs) at municipal wastewater treatment plants. The study at six municipal WWTPs included a range of facility sizes, locations, and treatment technologies. A combination of online process monitoring, offline sampling, electrical submetering, and specific performance efficiency testing techniques was used to obtain real-time process and electrical consumption data.

Recommendations varied for each site. They included piping modifications, pump and/or motor replacement, operational procedures changes, modification of online instrumentation and control systems, aeration system upgrades, and additional energy reuse options. The energy implications (savings or additional costs) were quantified for each item. The simple payback period for operational changes and minor capital items ranged from 0 to 15 years. Major capital items were recommended for reasons other than energy conservation, including worker health and safety, effluent quality, and/or capacity limitations.

The results of the study indicated that the audit approach, which consists of a systematic and rigorous methodology for obtaining accurate performance information, is an appropriate tool for identifying ECOs at existing wastewater treatment facilities. Online process data, equipment performance characteristics, and electrical submetering information provide a good basis for identifying ECOs, quantifying the achievable savings, and predicting the impact of implementation on facility performance.

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ABBREVIATIONS

BOD_5 5-day biochemical oxygen demand

BFP belt filter press

Btu British thermal units

$cBOD_5$ carbonaceous biochemical oxygen demand

COD chemical oxygen demand

DAF dissolved air flotation

DO dissolved oxygen

ECO energy conservation opportunities

F/Mv food to microorganism ratio

gpd gallons per day

gpm gallons per minute

hp horsepower

HRT hydraulic residence time

kW kilowatts

kWh kilowatt hours

lb/d pounds per day

mgd million gallons per day

mg/L milligram per liter

mL/g milliliter per gram

MLSS mixed liquor suspended solids

MLVSS mixed liquor volatile suspended solids

NH_3-N ammonia as nitrogen

NO_2-N nitrite as nitrogen

NO_3-N nitrate as nitrogen

PO_4 orthophosphate

$sBOD_5$ soluble biochemical oxygen demand

RAS return activated sludge

SOR surface overflow rate

SOTE standard oxygen transfer efficiency

SRT solids residence time

SVI sludge volume index

TKN total Kjeldahl nitrogen

TP total phosphorus

TS total solids

TSS total suspended solids

VS volatile solids

VSD variable speed drive

VSS volatile suspended solids

WAS waste activated sludge

SUMMARY

The New York State Energy Research and Development Authority (NYSERDA), the Empire State Electric Energy Research Corporation (ESEERCO), and the Electrical Power Research Institute (EPRI) funded an investigation of New York State wastewater treatment plants (WWTPs). The purpose of the investigation was to determine if process audit and electrical submetering techniques are an effective method of identifying energy conservation opportunities (ECOs) at municipal wastewater treatment plants. Phase 1 consisted of screening 80 potential WWTPs to identify six test sites to include in the study program. The sites were selected to provide a representative sample of the existing wastewater treatment facilities in New York State in terms of size (flow rate), location, treatment technologies, and sludge management practices. Table 1 lists the sites and their rated capacities. Table 2 lists the various treatment technologies included in the test program. Phase 2 consisted of an intensive four- to six-week field study at each site including operating data reviews, online process monitoring, offline sampling, performance efficiency testing, and electrical submetering. The objectives of the field testing were to quantify the energy consumption and process performance on a process-by-process and whole plant basis, to examine the dynamic interrelationships among the unit processes to determine load/response and effect on performance, and to identify areas for process improvements.

The ECOs identified during the study can be divided into four categories:

- maintenance and housekeeping items,
- operating and control procedures,
- electrical equipment replacement, and
- capacity-related issues.

TABLE 1
SIX MUNICIPAL WASTEWATER TREATMENT FACILITIES INCLUDED IN THE TEST PROGRAM

Name of Facility	Utility	Rated Capacity
Sodus WWTP, Sodus, NY	Rochester Gas and Electric	0.5 mgd
Goshen WWTP, Goshen, NY	Orange and Rockland	1.5 mgd
Marsh Creek WWTP, Geneva, NY	New York State Electric and Gas Corp.	4.0 mgd
Arlington STP, Poughkeepsie, NY	Central Hudson Gas and Electric	4.0 mgd
Bergen Point WWTP, Babylon, NY	Long Island Lighting Company	30.0 mgd
Yonkers Joint WWTP, Yonkers, NY	New York Power Authority	90.0 mgd

TABLE 2 LIQUID AND SOLIDS TREATMENT TECHNOLOGIES INCLUDED IN THE TEST PROGRAM	
Liquid Treatment Technology	**Solids Treatment Technology**
Pump stations	Thickeners Gravity belt Gravity Dissolved air flotation
Aerated grit chambers	Dewatering Belt filter press Centrifuge
Primary clarifiers	Anaerobic digestion
Activated sludge Extended aeration Contact stabilization Conventional activated sludge	Sludge composting
Aeration systems Coarse bubble Fine bubble Membrane panels	Incineration Fluidized bed Multiple hearth
Trickling filters	
Tertiary filtration	
Effluent polishing lagoons/wetlands	
Chlorination	

Several maintenance and housekeeping items were identified during the study. Common items included inoperable or worn backflow prevention valves on pumps, inappropriate or worn pressure relief valves on aeration blowers, inappropriate valve or gate settings, and worn pumps. The capital costs of replacing these items were usually very small and the payback period was usually less than two years.

The study recommended changes to operating procedures at several of the plants. These included changes to pump control strategies, provision of measurement and control of miscellaneous air use for common air supply systems, and changes to solids handling procedures. The capital costs for these changes were usually small to moderate and the payback period was usually less than five years.

All of the wastewater treatment plants included in the study were more than 20 years old, and there have been technological advances since the original electrical equipment was installed. At several sites the study recommended replacing older electrical motor and drive systems with more efficient units. The capital costs of these recommendations were moderate and the payback period was usually less than five years.

Excess capacity in one or more unit process was identified as contributing to increased energy consumption at many of the sites. Excess blower capacity as a result of upgrading from coarse- to fine-bubble aeration, excess aeration basin volume, and excess solids stabilization capacity were identified. Recommendations included taking basins out of service, downsizing equipment, and providing intermediate storage between processes to allow for different loading rates. At two of the sites the study recommended that the facility use the excess capacity in the solids handling and treatment systems to treat hauled sludge from neighbouring facilities as an income-generating opportunity. The capital costs of these recommendations varied from very low (taking units out of service) to high (constructing hauled sludge receiving facilities). The payback period varied from less than one year to more than 10 years.

This project used a combination of process audit, energy audit, and electrical submetering techniques to identify low-capital-cost methods of improving the performance and energy efficiency of six WWTPs in New York State. The plants were selected to provide a representative sample in terms of size, location, and treatment technologies. The plants were operating well within their effluent discharge requirements and provided good to excellent levels of treatment.

One of the primary objectives of the study was to determine if this approach is an effective method of reducing WWTP operating costs and improving WWTP performance. There were several advantages to this approach:

- Real-time data provides a greater understanding of the dynamic response characteristics of the treatment processes. The impact of energy conservation recommendations on treatment performance is easier to foresee if the real-time process performance data is available.

- Measured electrical consumption data is required to determine the potential energy savings associated with implementing ECOs. Using a single power draw measurement may over- or underestimate the potential savings.

- Real-time process and performance data is required to evaluate theoretical versus achievable energy savings associated with implementing ECOs. The data can also indicate methods of increasing the achievable savings.

- Discrepancies or unexpected results in the data generated are good indicators of potential areas of improved performance that may be overlooked using more traditional approaches.

The audit approach, which consists of a systematic and rigorous methodology for obtaining accurate performance information, is an appropriate tool for identifying ECOs at existing wastewater treatment facilities. Online process data, equipment performance characteristics, and electrical submetering information are required to predict the effects of implementing ECOs. The conceptual approach used for this project was quite simple. Measure what you have, what you are using, and the performance achieved, and base decisions for improving performance efficiency on the measured data.

Section 1
INTRODUCTION

PROJECT OBJECTIVES

The New York State Energy Research and Development Authority (NYSERDA), the Empire State Electric Energy Research Corporation (ESEERCO), and the Electric Power Research Institute (EPRI) jointly funded an investigation of New York State wastewater treatment plants (WWTPs). The purpose of the investigation was to determine if process optimization of the WWTPs without major capital expenditure and the identification of potential energy-saving measures within existing facilities were effective methods of reducing plant operating costs and improving plant performance.

The project was conducted in two phases. Phase 1, which was completed in 1995, consisted of screening 80 potential WWTPs to identify six test sites for the field monitoring portion of the project. The intent was to provide a representative sample of the WWTPs in New York State in terms of size (flow rate), treatment technologies, and sludge management practices.

Phase 2 used a combination of operating data review, online process monitoring, offline sampling, electrical submetering, and specific performance efficiency testing techniques to quantify the treatment provided and energy consumed on a unit process and whole plant basis. The overall objectives of the field testing were to:

- quantify the energy consumption and process performance on a process-by-process and whole plant basis at each WWTP;

- examine the dynamic interrelationships among the various unit processes at each site, including loading response and its effect, on unit process and whole plant energy use, performance, and treatment efficiency;

- identify areas for process improvements including making changes to treatment process control and operating procedures or installing electro-technologies, and low-capital-cost equipment changes, to improve energy efficiency, treatment performance, and capacity at each WWTP.

TEST METHODOLOGY

The facility performance was evaluated in detail over a four- to six-week period. A minimum of 12 months of operating data was reviewed to determine the current baseline unit process loading and performance and energy consumption pattern, and to identify factors that may be limiting the facility performance.

The offline sampling consisted of collection and analysis of 24-hour composite samples from upstream and downstream of each unit process supplemented with grab samples from various locations. The analytical results were used to determine unit process loading and performance on a daily basis and to characterize recycle streams through the plant. The offline sampling also provided a quality control check for the online process data collected.

Real-time data was collected from the existing and temporary online process monitoring equipment. The types of online process data collected varied between sites. In general, the data included wastewater flow, air flow, aeration basin dissolved oxygen concentration, mixed liquor concentration, return activated sludge flow, and effluent suspended solids concentration. The online process data was used to quantify the dynamic load/response characteristics of the unit processes.

The whole-facility energy use was recorded on a 15-minute basis by the local utility. The energy use of the process-related equipment was monitored with temporary submetering equipment installed during the field test period. For motors where the load was not expected to vary significantly during use, time-in-use loggers were installed to record off/on events. Current transducers and voltage-potential wires were installed at the breaker panel for motors that experience significant variations in loading during normal operation.

Specific performance tests were conducted on the major energy end users to obtain in situ performance data. Performance testing consisted of oxygen transfer efficiency testing, digester tracer testing, and "wire to water" efficiency testing of the major process equipment.

The detailed results of the field work are presented in a separate site report for each facility. Copies of the individual site reports are available through NYSERDA. This report presents a summary of results from the six wastewater treatment plants included in the study.

TEST SITES

Table 1-1 lists the six municipal wastewater treatment plants and the corresponding treatment technologies included in the study. The facilities ranged in size from 0.5 mgd to 90 mgd capacity and included two small (< 2 mgd), two medium (2 to 10 mgd), and two large (> 10 mgd) plants. All of the sites provided a minimum of secondary level treatment. The two smaller sites also provided tertiary treatment.

TABLE 1-1
SIX MUNICIPAL WASTEWATER TREATMENT PLANTS INCLUDED IN THE TEST PROGRAM

Name	Capacity (mgd)	Liquid Treatment Processes	Solids Treatment Processes
Sodus Village WWTP	0.5	Grit channel Primary clarification Trickling filter Extended aeration Fine bubble aeration Tertiary sand filter	Anaerobic digestion Sludge drying
Village of Goshen WWTP	1.5	Grit channel Primary clarification Trickling filter Treatment wetlands Chlorination	Anaerobic digestion Sludge drying
Marsh Creek WWTP	4.0	Aerated grit removal Primary clarification Complete mix AS Panel membrane aeration Chlorination	Gravity thickening Anaerobic digestion Beltpress dewatering Composting
Arlington STP	4.0	Aerated grit removal Primary clarification Plug flow AS Coarse bubble aeration Chlorination	Gravity thickening Beltpress dewatering Fluidized bed incineration
Bergen Point WWTP	30	Scavenger waste facility Raw sewage pumping Aerated grit removal Primary clarification Step feed AS Panel membrane aeration Chlorination	Gravity thickening Gravity belt thickening Belt press dewatering Multiple hearth incineration
Yonkers Joint WWTP	90	Aerated grit removal Primary clarification Plug flow AS Coarse bubble cross roll aeration Chlorination	Gravity thickening Dissolved air flotation Anaerobic digestion Centrifuge dewatering

Section 2

WASTEWATER TREATMENT PLANT CONFIGURATIONS AND PERFORMANCE

The six wastewater treatment plants included in the study were chosen to provide a representative sample of the range of facility sizes, locations, and treatment technologies currently operating in New York State. The following sections provide a brief description of each facility, its recent performance history, and the field test procedures and results.

Field testing consisted of offline sampling, online monitoring, and performance testing of specific equipment and processes. The offline sample results are based on 24-hour composite samples and grab samples taken at various points in the process. The online data consists of data measured from temporary instruments installed for the test period, supplementing the data collected by the existing permanent online metering equipment at each site.

SODUS VILLAGE WWTP

Figure 2-1 presents a flow schematic and Table 2-1 summarizes the unit processes of the Sodus Village WWTP. The rated capacity of the WWTP is 0.5 mgd and the current measured average-day flow is 0.38 mgd. The WWTP discharge permit has seasonal limits for 5-day biochemical oxygen demand (BOD_5), total suspended solids (TSS), and ammonia-nitrogen (NH_3-N). During the summer months the criteria are 5 mg/L, 10 mg/L, and 2.0 mg/L, for BOD_5, TSS, and NH_3-N, respectively. The dissolved oxygen (DO) concentration of the final effluent must be greater than 7 mg/L. During the winter months the criteria are 25 mg/L and 30 mg/L for BOD_5 and TSS, respectively. There is no NH_3-N discharge criterion for the winter months.

Raw wastewater flows by gravity through a grit channel prior to entering the primary clarifier. Grit removed from the wastewater in this channel is disposed of offsite. The degritted wastewater flows by gravity to a single primary clarifier. Filter backwash from the tertiary sand filter, digester supernatant, and sludge concentrator supernatant is mixed with degritted wastewater upstream of the primary clarifier. Sludge from the primary clarifier is pumped to the sludge well.

Following primary clarification, the wastewater flows by gravity to the trickling filter. Trickling filter effluent is pumped back through the filter as recycle. Alternatively, the trickling filter can be bypassed, in which case primary effluent flows by gravity directly to the aeration basin.

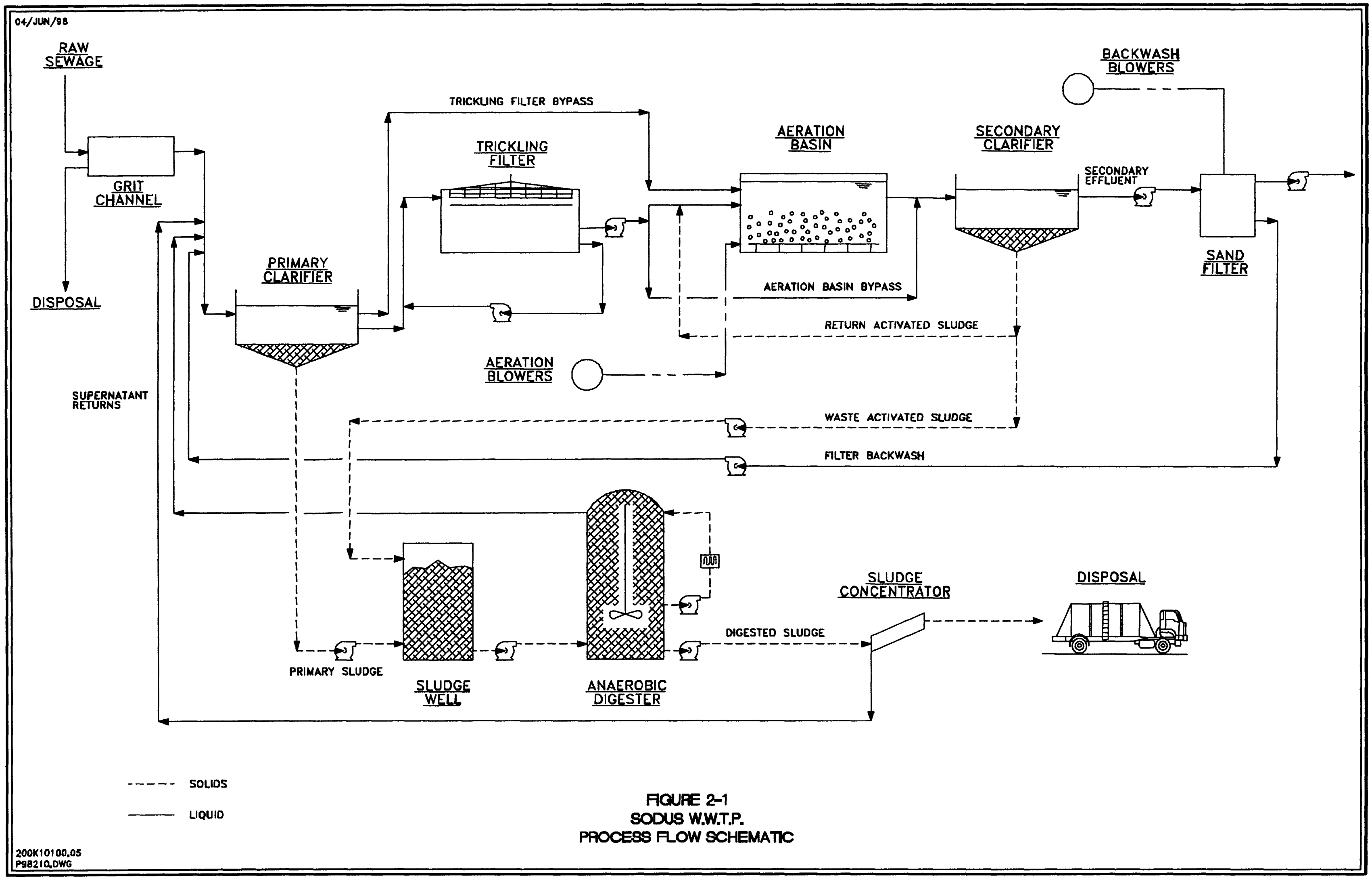

FIGURE 2-1
SODUS W.W.T.P.
PROCESS FLOW SCHEMATIC

TABLE 2-1 SODUS VILLAGE WWTP - SUMMARY OF UNIT PROCESSES		
Unit Process	**Number**	**Description**
Primary clarifier	1	Area = 616 ft^2 Volume = 32,224 gal. Diameter = 28 ft
Trickling filter	1	Media depth = 5 ft 3 in. Diameter = 35 ft
Aeration basin	1	Area = 2,640 ft^2 Depth = 15 ft Volume = 296,208 gal.
Diffusers		Fine bubble Rubber sock Submergence depth = 14 ft
Aeration blowers	5	10 hp each
Secondary clarifier	1	Area = 616 ft^2 Volume = 32,224 gal. Diameter = 28 ft
Tertiary sand filter	1	Area = 352 ft^2 total 2 blowers at 10 hp each
Digester	1	Volume = 95,000 gal.
Sludge concentrator	1	Screw conveyor

The trickling filter effluent is pumped to the aeration basin. Air is supplied through fine-pore rubber sock diffusers by five 10-hp blowers. There is also a bypass of the aeration basin that sends trickling filter effluent flow directly to the secondary clarifier. Bypassing is done to reduce the solids loading on the secondary clarifier during high flow conditions. The solids concentration in the trickling filter effluent is significantly less than the solids concentration in the aeration basin. The operator estimates that approximately 50 percent of the total plant flow bypasses the aeration basin.

The wastewater flows by gravity from the aeration basin to the secondary clarifier. Sludge from the secondary clarifier is removed from the bottom of the clarifier, the return activated sludge (RAS) is returned to the head of the aeration basin, and the waste activated sludge (WAS) is pumped to the sludge well. The RAS and WAS flow rates are not measured.

Secondary effluent is pumped to the effluent sand filter. Backwash operations of the filter are controlled by level sensors and each cell is backwashed at least once a day. There are two 10-hp backwash blowers. One blower operates continuously to provide reaeration of the filter effluent.

Sludge is pumped from the sludge well to the anaerobic digester. The sludge is recirculated through a heat exchanger and is continuously mixed in the digester. The digested sludge is pumped from the digester to a sludge concentrator for dewatering. The dewatered sludge is disposed of offsite.

Performance History

The average monthly flow to the Sodus Village WWTP between January 1986 and December 1995 was 0.34 mgd. Since 1986, the flow has been increasing at a rate of approximately 0.013 million gallons per year. The average monthly BOD_5 and the TSS loads to the plant between January 1986 and December 1995 were 495 and 470 lb/day, respectively. The average TSS and BOD_5 concentrations in the raw sewage were 168 and 174 mg/L, respectively.

When the aeration basin at the Sodus Village WWTP went online in January 1991, the final effluent quality improved dramatically. Prior to 1991, the average concentrations were 31 mg/L for BOD_5, 23.4 mg/L for TSS, and 19.2 mg/L for NH_3-N. After 1991, the effluent concentrations improved to 7.9 mg/L for BOD_5, 5 mg/L for TSS, and 3.7 mg/L for NH_3-N.

During the summer months between 1991 and 1995, average monthly final effluent concentrations were 5.0 mg/L, 4.3 mg/L, and 1.7 mg/L, for BOD_5, TSS, and NH_3-N, respectively. These compare with the summer discharge criteria of 5 mg/L for BOD_5, 10 mg/L for TSS, and 2.0 mg/L for NH_3-N. During the winter months the average monthly final effluent concentrations were 9.0 mg/L, 5.9 mg/L, and 4.5 mg/L, for BOD_5, TSS, and NH_3-N, respectively. These compare to the winter discharge criteria of 25 mg/L for BOD_5 and 30 mg/L for TSS. There is no discharge criterion for NH_3-N during the winter.

The average removal efficiencies of BOD_5, TSS, and NH_3-N for the Sodus WWTP between January 1986 and December 1995 were 78 percent for BOD_5, 85 percent for TSS, and 58 percent for NH_3-N. After 1991 the removal efficiencies improved to an average of approximately 96 percent for both BOD_5 and TSS, and 82 percent for NH_3-N.

The current discharge permit for the Sodus WWTP requires 85 percent removal efficiency for both BOD_5 and TSS. The removal efficiency for BOD_5 was in excess of 85 percent 95 percent of the time and for TSS was in excess of 85 percent 98 percent of the time.

The mixed liquor suspended solids (MLSS) concentration for the aeration basin at the Sodus WWTP was 3,852 mg/L. High MLSS concentrations during the winter months of 1995 were the result of solids-handling limitations during the winter. The sludge concentrator was not in a heated facility and therefore the WWTP operator was not able to remove solids from the aeration basin. This situation has been corrected and the MLSS concentrations have since decreased.

The average sludge volume index (SVI) for the Sodus WWTP from January 1995 to October 1996 was 139 mL/g. The SVI is used as an indicator of the settling characteristics of a sludge. Values greater than 200 mL/g are associated with poorly settling sludge. The maximum SVI between January 1995 and October 1996 was 176 mL/g.

The monthly average sludge volume feed to the digester was approximately 88,850 gallons, and the monthly average discharge from the digester was 41,150 gallons. The difference between the volume of sludge pumped to and the volume of sludge discharged from the digester (approximately 47,700 gallons) is the amount of supernatant returned to the head of the plant from the digester.

The average monthly electrical usage for the Sodus Village WWTP between July 1995 and October 1996 was 22,815 kWh/month, and the average monthly natural gas usage was 670 therm/month (1 therm = 100,000 Btu). During the winter months the natural gas consumption increased to 1,113 therm/month. Natural gas is used to heat the digesters.

Field Test

The Sodus Village WWTP field test program was conducted from June 4 to June 28, 1996. Table 2-2 presents the unit process loadings and effluent quality during the field test program and historical values for the facility. The hydraulic and organic loading during the field test program was similar to the historical data for the facility. However, the final effluent characteristics were significantly different. The field test final effluent characteristics were determined based on 24-hour composite samples collected every second day. These concentrations are likely a more accurate reflection of the loading and treatment provided by the Sodus Village WWTP.

Field testing consisted of offline sampling, online monitoring, and performance testing of specific equipment and processes. The offline sampling results were based on 24-hour composite samples and grab samples taken at various points in the process. The online data consists of data measured from temporary instruments installed for the test period and from existing permanent metering equipment onsite. The temporary instruments included DO probes installed in the aeration basin, a solids probe in the aeration basin to measure mixed liquor suspended solids concentration, and a

TABLE 2-2
SODUS VILLAGE WWTP - SUMMARY OF UNIT PROCESS LOADING DURING FIELD TEST PROGRAM

Unit Process	Units	Field Test		Historical	
		Average	Maximum	Average	Maximum
Loading					
Hydraulic	Mgd	0.34	0.46	0.38	0.48
Organic					
BOD_5	mg/L	126	280	174	260
BOD_5	lb/d	339	710	613	949
TSS	mg/L	172	500	168	310
TSS	lb/d	475	1,691	530	849
NH_3-N	mg/L	NA	NA	24	32
Effluent Quality					
BOD_5	mg/L	19	40	7.9	
TSS	mg/L	11	28	5	
NH_3-N	mg/L	6.7	19	3.7	
Primary Clarifier					
Area	ft^2	616		616	
Surface overflow rate	gpd/ft^2	551	750	620	780
Aeration Basin					
Volume	ft^3	39,600		39,600	
BOD_5 loading	lb/day*1,000 ft^3	8.3	18	NA	NA
HRT	hour	21	15	18.7	14.8
MLSS concentration	mg/L	3,763	4,800	3,852	8,904
SVI	mL/g	NA	NA	139	176
F/M	$days^{-1}$	0.06	0.1	NA	NA
Secondary Clarifiers					
Area	ft^2	616		616	
Surface overflow rate	gpd/ft^2	551	750	620	780
Tertiary Sand Filter					
Area	ft^2	352		352	
Hydraulic loading	gpm/ft^2	0.66	0.9	0.75	0.95
Digesters					
Primary volume	gal.	95,000		95,000	
Feed	gal./month	44,300		88,840	
Discharge	gal./month	30,500		41,140	
HRT	days	65		33	

solids probe in the secondary effluent well to measure secondary effluent suspended solids concentration. The total plant flow was measured by the existing plant flow meter. The performance testing consisted of oxygen transfer efficiency testing of the aeration equipment and pump performance tests.

Table 2-3 presents a summary of the field test activities. Detailed test descriptions and results are presented in the Sodus Village WWTP Site Report (CH2M HILL, 1998e).

TABLE 2-3
SODUS VILLAGE WWTP - FIELD TEST PROGRAM

Offline Sampling Program

Sample Location	Frequency	Type of Sample	Analysis
Raw sewage	2nd day	24 h	$cBOD_5$, TSS, VSS
Primary effluent	2nd day	24 h	$cBOD_5$, NH_3-N, TKN, TSS, VSS
Trickling filter effluent	2nd day	24 h	$cBOD_5$, NH_3-N, TKN, TSS, VSS
Secondary effluent	2nd day	24 h	$cBOD_5$, NH_3-N, TKN, TSS, VSS
Sand filter effluent	2nd day	24 h	$cBOD_5$, TSS, VSS
Sludge concentrator supernatant	1/operation	grab	$cBOD_5$, TSS, VSS
Filter backwash	1/week	grab	$cBOD_5$, TSS
Digester supernatant		grab	$cBOD_5$, TKN, TSS
Raw sludge		grab	TS, TVS
Digested sludge		grab	TS, TVS
Digester profile (5 ports)		grab	TS, TVS
MLSS	2/week	grab	TSS, VSS
RAS	2/week	grab	TSS

Online Monitoring Program

Location	Type	Data
Aeration basin	Dissolved oxygen Suspended solids	4 temporary meters 1 temporary meter
Secondary effluent	Suspended solids	1 temporary meter
Raw sewage	Flow	1 existing meter – flume

Performance Testing

Location	Type	Analysis
Aeration basin	Offgas	Oxygen transfer efficiency
Pumps	Performance	"Wire to water" efficiency

The major conclusions from the field study period for the Sodus Village WWTP were:

- The average BOD_5 and TSS removal efficiencies were 25 and 38 percent, respectively. Typical BOD_5 and TSS removal efficiencies for primary clarifiers are 35 and 65 percent, respectively. The poor performance was likely due to solids buildup in the clarifier. The solids were removed once or twice per week.

- The trickling filter was providing only minimal treatment under current loading conditions.

- The aeration basin operated as an extended aeration facility. The existing aeration equipment was able to maintain the DO concentration over 1.0 mg/L at all times. The average DO was greater than 3.0 mg/L for significant periods during the study.

- The measured standard oxygen transfer efficiency (SOTE: 20°C, 0 mg/L DO) of the existing aeration equipment was 21 percent.

- Pressure relief valves on the air piping were open between the aeration blowers and the aeration basin, resulting in a constant venting of pressurized air to atmosphere.

- The secondary clarifiers were not performing as expected. This was likely due to a solids flux failure and bottlenecks in removing settled solids from the clarifier.

- The secondary effluent solids concentration regularly increased during the day. The pattern observed indicated a solids flux limitation in the clarifier. The solids removal mechanisms and RAS pumps should be upgraded if the secondary clarifier remains in service.

- The NH_3-N concentration in the final effluent averaged 6.7 mg/L, which is greater than the effluent discharge requirement of 2.0 mg/L. This was likely the result of directing flow from the trickling filter to the secondary clarifier, thus bypassing the aeration basin. The operators bypassed the aeration basin to reduce the solids loading to the secondary clarifier. The trickling filter did not provide nitrification under current loading conditions.

- The check valves on the secondary pumps were not operating correctly, resulting in pumped secondary effluent being returned to the wet well through the standby pump.

- The biogas collection system for the anaerobic digester was inoperable. The digester cover was corroded and leaked biogas to the atmosphere. The gas collection system was plugged and the digester was venting through the emergency overflow vent. This represented a significant health and safety concern for the site, as well as a loss of useable energy.

VILLAGE OF GOSHEN WWTP

Figure 2-2 presents a flow schematic and Table 2-4 summarizes the unit processes of the Village of Goshen WWTP. Wastewater, consisting mainly of domestic, institutional, and commercial sewage, flows by gravity to the WWTP. The design capacity of the WWTP is 1.5 mgd and the current measured average day flow is 1.23 mgd. The discharge criteria for the facility are 25 mg/L BOD_5 and 25 mg/L TSS.

The wastewater flows by gravity through a manually cleaned bar screen and grit chamber to a distribution box that divides the flow among three primary clarifiers. The screenings and grit are transported to a landfill. After primary clarification, the wastewater flows by gravity through two trickling filters to the trickling filter wet well, where it is pumped to the secondary clarifiers.

Wastewater from the secondary clarifiers flows by gravity through the chlorine contact chamber to the two effluent polishing lagoons. The effluent polishing lagoons are operated in series. The treated effluent is discharged into the Rio Grande Creek.

Solids from the secondary clarifiers are pumped on a continuous basis to the primary clarifier distribution box for co-settling in the primary clarifier. The combined sludge from the primary clarifier is pumped twice per day to the primary anaerobic digester. A dual fuel gas boiler is used to heat the digester contents. The digester is mixed for approximately 16 hours per day with a digester recirculation pump. The primary digester mixing pumps are switched off for approximately eight hours each day when the combined sludge is pumped into the primary digester.

Digested sludge flows by gravity from the primary to the secondary digester. Supernatant from the secondary digester flows by gravity to the primary clarifier distribution box. Digested sludge is

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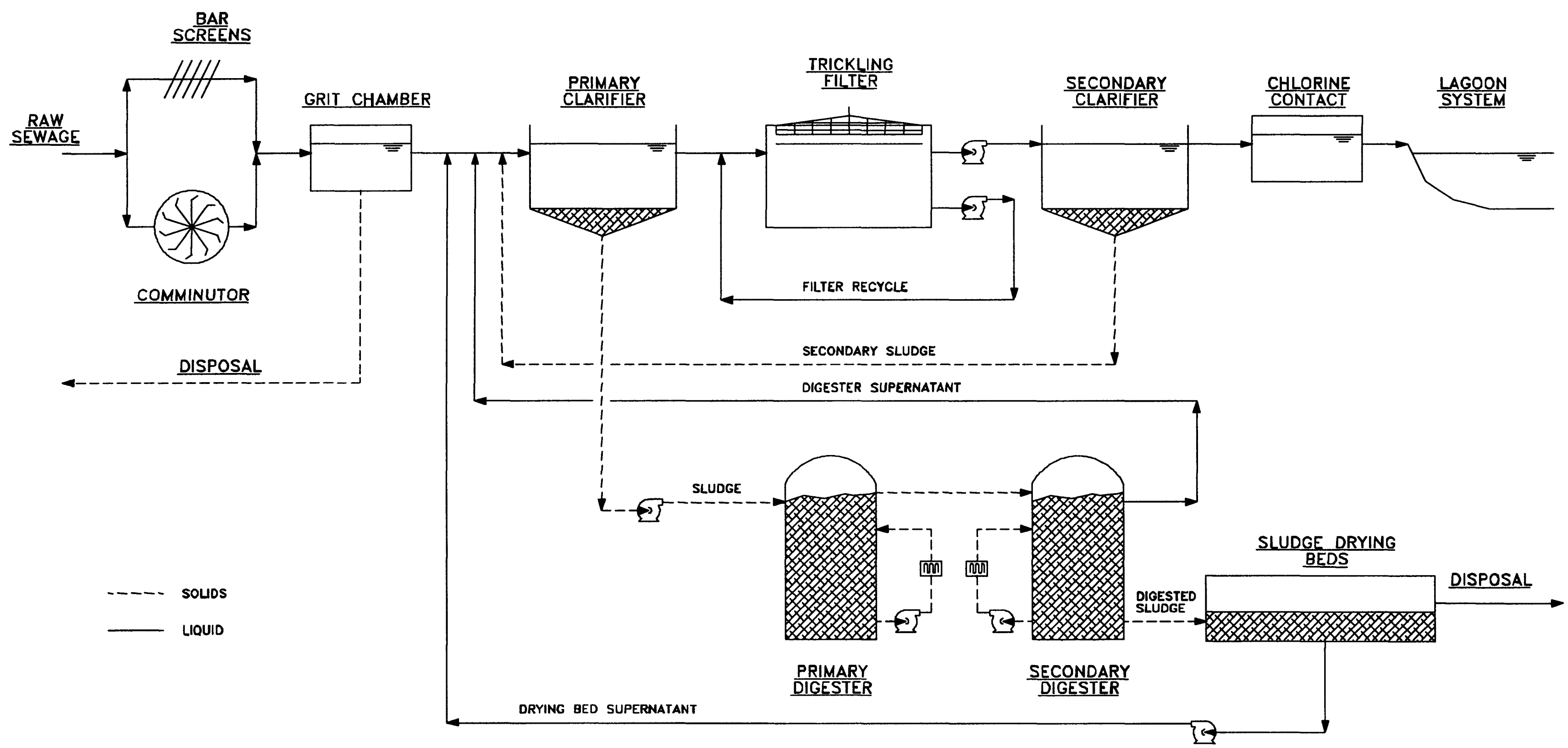

FIGURE 2-2
GOSHEN W.W.T.P.
PROCESS FLOW SCHEMATIC

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P98206.DWG

TABLE 2-4 VILLAGE OF GOSHEN WWTP - SUMMARY OF UNIT PROCESSES		
Unit Process	**Number**	**Description**
Bar screen	1	Manual cleaned
Grit chamber	1	Circular
Primary clarifier	2	Area = 768 ft^2 (per unit) 64 ft x 12 ft; 7.25 ft deep
	1	Area = 960 ft^2 (per unit) 60 ft x 16 ft; 7 ft deep
Trickling filter	2	Area = 2,827 ft^2 (per unit) Volume = 19,792 ft^3 Dia. = 60 ft; rock 7 ft deep
Secondary clarifier	2	Area = 936 ft^2 52 ft x 18 ft; 6.5 ft deep
Chlorine contact chamber	1	Area = 828 ft^2 Volume = 4,140 ft^3
Polishing lagoons	1	Area = 10.5 acres Volume = 3.85 million gal.
	1	Depth 12 to 15 inches Area = 10.5 acres Volume = 15.4 million gal. Depth 4.5 feet
Digester	1	Primary digester - fixed roof Max volume = (25,450 ft^3) 190,400 gal. Dia. = 45 ft; SWD = 16 ft
	1	Secondary digester - floating roof Max volume = (35,000 ft^3) 261,800 gal. Dia. = 45 ft; SWD = 19 ft
Sludge drying beds	4	Area = 11,250 ft^2 (per unit)

removed from the secondary digester every 45 to 60 days. Approximately 25 to 30 cubic feet of digested sludge are removed from the secondary digester and placed on sludge drying beds. The drainage from the sludge drying beds is pumped to the primary clarifier distribution box.

Performance History

The average-day flow for the Village of Goshen WWTP for June 1995 to June 1996 was 1.23 mgd. However, the flow is highly variable. During dry weather periods (June through September 1995) it averaged between 0.7 and 1.0 mgd. During wet weather it increased to over 3.0 mgd. The flow distribution pattern indicated there was a significant contribution from infiltration/inflow in the raw sewage flow to the plant.

The historical TSS and BOD_5 loadings to the Village of Goshen WWTP averaged 1,350 and 1,190 lb/day, respectively. The Sorrento cheese factory is the only major industrial source in the sewerage area. During the first quarter of 1995, Sorrento's pretreatment system (activated sludge) experienced process upsets, resulting in an increase in the organic load to the plant. As a result, the TSS and BOD_5 loadings were significantly greater during the first quarter of 1995. The average TSS and BOD_5 concentrations for January, February, and March 1995 were 241 and 173 mg/L, respectively. The average TSS and BOD_5 concentrations for the 19-month period of record examined were 135 and 124 mg/L, respectively.

The TSS and BOD_5 concentrations in the final effluent from the Village of Goshen WWTP from January 1995 to June 1996 were 3.8 and 2.8 mg/L, respectively. This is well below the effluent discharge requirement of 25 mg/L for BOD_5 and 25 mg/L for TSS. The average TSS and BOD_5 removal efficiencies were 96.6 percent and 97.2 percent, respectively. The WWTP provides a very high standard of treatment. The BOD_5 and TSS removal efficiencies were greater than 90 percent for more than 98 percent of the time over the 18-month period examined.

The average daily volume of sludge pumped to the primary digester was 8,083 gallons per day. The solids concentration in the co-settled sludge was not measured. The flow control gate on the sludge withdrawal line from each clarifier is opened manually.

The average electrical consumption from November 1994 to July 1995 was 870 kWh per day. The energy use remained significantly higher during the winter months. This was likely due to the increase in flow rate and electrical heating requirements during the winter.

The average propane consumption from 1993 to 1996 was 9,925 gallons per year. Propane is used to heat the primary digester. During the summer months of 1993 and 1994, biogas collected from the primary digester was used for most of the heating requirements. During 1995 and 1996, the WWTP was not able to collect biogas and therefore average propane consumption increased from 20.3 to 34.1 gallons per day.

Field Test

The Village of Goshen WWTP field test program was conducted from July 16 to August 15, 1996. Table 2-5 presents a comparison between the unit process loadings and effluent quality during the field test program and historical values for the facility. The hydraulic loading to the treatment plant was similar to the historical values. However, the raw sewage BOD_5 and TSS concentrations were significantly lower. The average BOD_5 and TSS concentrations during the test period were 67.2 and 88.9 mg/L, respectively. Therefore, the organic loading on the Village of Goshen WWTP was approximately half of the historical average for the facility.

TABLE 2-5 VILLAGE OF GOSHEN WWTP – SUMMARY OF UNIT PROCESS LOADING DURING FIELD TEST PROGRAM

Unit Process	Units	Field Test		Historical	
		Average	Maximum	Average	Maximum
Loading					
Hydraulic	Mgd	1.16	3.28	1.23	3.41
Organic					
BOD_5	Mg/L	67.2	96	124	
	lb/d	571	829	1,193	2,203
TSS	mg/L	88.9	134	135	
	lb/d	807	1270	1,352	2,841
Effluent Quality					
BOD_5	Mg/L	1.9	3.0	2.8	
TSS	Mg/L	3.2	6.0	3.8	
Primary Clarifier					
Surface overflow rate	Gpd/ft^2	464	1,314	492	1.362
Trickling Filter					
Surface wetting rate	Gpm/ft^2	0.14	0.40	0.15	0.42
BOD_5 loading rate [a]	lb/d 1,000ft^3	7.8	16.6	19.6	36.2
Secondary Clarifiers					
Surface overflow rate	Gpd/ft^2	620	1,752	657	1,822
Chlorine Contact Chamber					
Hydraulic residence time	Min	38	14	36	13
Effluent Polishing Lagoons					
Lagoon 1 HRT	Day	3.3	1.2	3.1	1.1
Lagoon 2 HRT	Day	13.3	4.7	12.5	4.5
Total	Day	16.6	5.9	15.6	5.6
Primary Digester					
Hydraulic residence time[b]	Day	23.8		23.5	
VS loading [c]	VSS lb/day	400			

Notes:
[a] Based on primary effluent average and maximum BOD_5 of 311 and 658 lb/day, respectively
[b] Based on measured sludge pump rate
[c] Based on mass balance around the primary clarifier

Field testing consisted of offline sampling, online monitoring, and performance testing of specific equipment and processes. The offline sampling results were based on 24-hour composite samples and grab samples collected at various points in the process. The online data consisted of data from existing flow metering equipment supplemented with a temporary solids concentration meter in the secondary clarifier effluent. The performance testing consisted of stress testing of the primary and secondary clarifiers, a mixing evaluation of the primary digester, and performance testing of the secondary effluent pumps. Table 2-6 summarizes the work done. Detailed test descriptions and results are presented in the Village of Goshen WWTP Site Report (CH2M HILL, 1998c).

TABLE 2-6
VILLAGE OF GOSHEN WWTP - FIELD TEST PROGRAM

Offline Sampling Program			
Sample Location	**Frequency**	**Type of Sample**	**Analysis**
Raw sewage	2^{nd} day	24 h	$cBOD_5$, TSS, VSS, NH_3-N, BOD_5, NO_2-N, NO_3-N, TKN
Primary effluent	2^{nd} day	24 h	$cBOD_5$, NH_3-N, TKN, TSS, VSS, BOD_5, NO_2-N, NO_3-N
Trickling filter effluent	2^{nd} day	24 h	TSS, VSS, $cBOD_5$, BOD_5, NH_3-N, NO_2-N, NO_3-N
Secondary effluent	2^{nd} day	24 h	$cBOD_5$, NH_3-N, TKN, TP, TSS, VSS, BOD_5, NO_2-N, NO_3-N
Digester supernatant	1/week	grab	$cBOD_5$, TKN, TP, TSS
Co-settled sludge	2/week	grab	TSS, VSS

Online Monitoring Program		
Location	**Type**	**Data**
Secondary effluent	Flow Suspended solids	1 existing meter - weir 1 temporary meter

Performance Testing		
Location	**Type**	**Analysis**
Primary clarifier	Stress test	Capacity
Secondary clarifier	Stress test	Capacity
Pumps	Performance	"Wire to water" efficiency
Digester	Profile	Mixing

The main conclusions from the field study of the Village of Goshen WWTP were:

- Primary clarifier performance was poorer than expected. This was partly due to poor hydraulic distribution among the three clarifiers.

- The secondary sludge pumps operated continuously, recycling an excessive amount of water through the plant.

- The secondary pump on/off operation resulted in frequent pump cycling and continual small hydraulic perturbations to the secondary clarifier. This had a significant negative impact on clarifier performance.

- The hydraulic throughput of the plant was less than 3.5 mgd. Significant hydraulic bottlenecks occurred at the plant headworks, between the primary clarifier and trickling filter, and at the chlorine contact chamber outfall.

- The measured capacity of the primary clarifiers was 1.5 mgd. The capacity could be increased by improving the flow distribution between the clarifiers.

- The measured capacity of the secondary clarifiers was 3.0 mgd. The secondary clarifier performance was reduced due to the on/off operation of the secondary pumps.

MARSH CREEK WWTP

Figure 2-3 presents a flow schematic and Table 2-7 summarizes the unit processes of the Marsh Creek WWTP. Wastewater flows by gravity to the WWTP and consists mainly of domestic and commercial sewage. Hauled leachate is brought to the plant and mixed with the raw sewage upstream of the primary clarifier. The rated capacity is 4.0 mgd and the average day flow is 3.35 mgd. There are no bypass structures. All wastewater generated by the catchment area must be treated by the plant. The discharge criteria for the facility are 30 mg/L BOD_5, 30 mg/L TSS, and 1.0 mg/L total phosphorus (TP).

The wastewater flows by gravity through the primary clarifiers, aeration basins, and the secondary clarifiers, and receives chlorination before discharge. Primary sludge pumped from the primary

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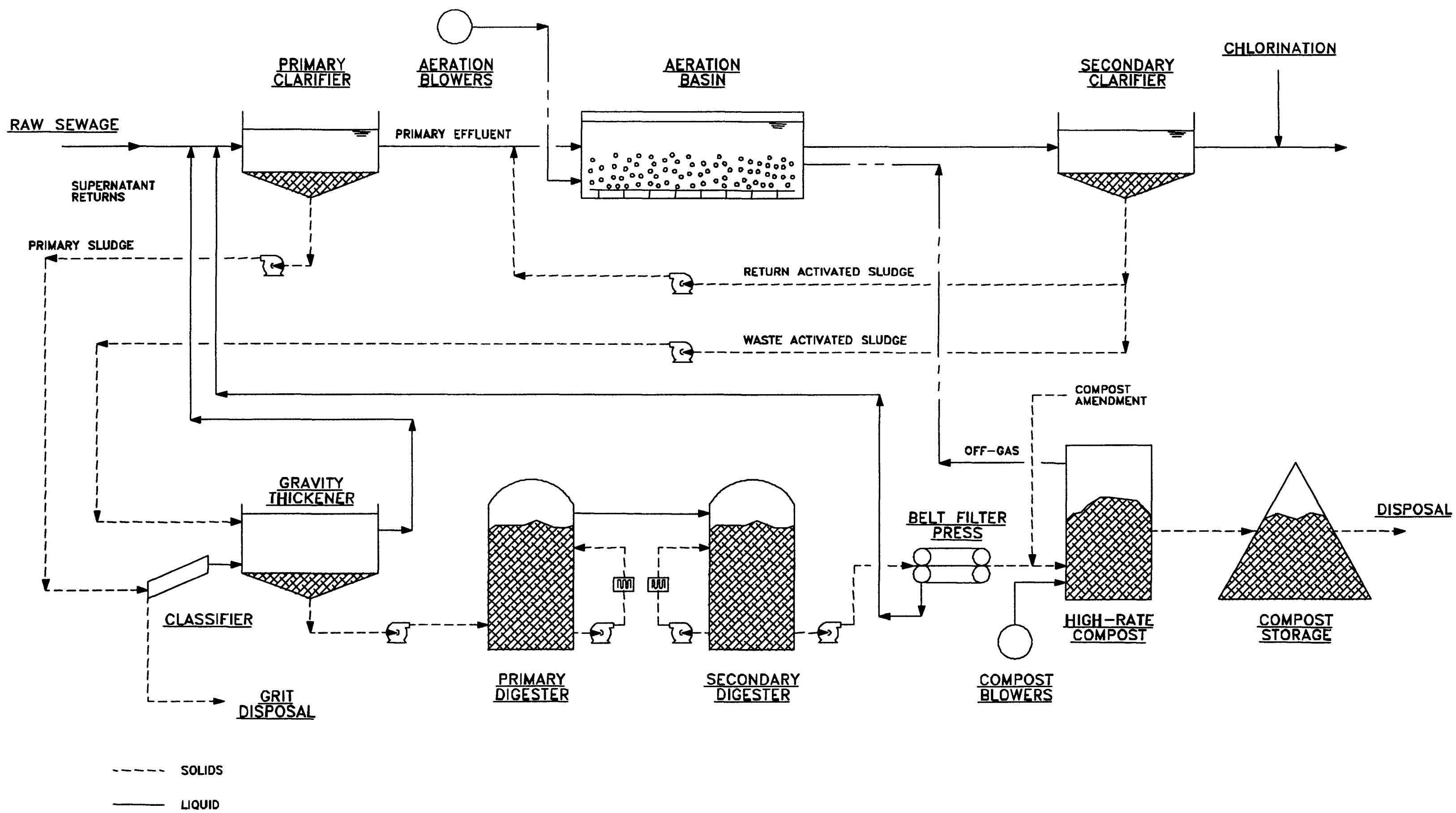

FIGURE 2-3
MARSH CREEK W.W.T.P.
PROCESS FLOW SCHEMATIC

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TABLE 2-7
MARSH CREEK WWTP – SUMMARY OF UNIT PROCESSES

Unit Process	Number	Description
Primary clarifier	2	Area = 707 ft^2 (per unit) Volume = 211,792 gal. (total) Diameter = 30 ft
Aeration basin	2	Area = 3,384 ft^2 (per unit) Volume = 750,000 gal. (total) Depth = 14' 5"
Diffusers		Fine bubble Area per diffuser = 48 ft^2 Number per tank = 38 Submergence = 13' 11"
Aeration equipment blowers	2 1	60 hp Variable speed, manually controlled 100 hp Variable speed, manually controlled
Secondary clarifier	2	Area = 707 ft^2 (per unit) Volume = 211,792 gal. (total) Diameter = 30 ft
Gravity thickener	2	Volume = 77,141 gal. (per unit) Dia. = 25 ft^2 Side wall depth = 16.5 ft
Digester	1 1	Primary Volume = 500,000 gal. Secondary Volume = 500,000 gal.
Belt filter press	1	Width = 6 ft
Compost facility	1	Capable of producing 2.5 dry tons of finished product per day

clarifiers passes through a grit classifier and then is pumped to a gravity thickener. Grit removed by the classifier is disposed of offsite.

Air is supplied to the aeration basin by one 100-hp and two 60-hp blowers through fine bubble membrane panel diffusors. WAS removed from the secondary clarifier is pumped to a gravity thickener prior to being pumped to the primary digester.

There is one primary digester and one secondary digester. Sludge is fed to and removed from the digesters by pumps. Hot water circulation is used to maintain the temperature in both digesters.

Methane gas produced by the digesters is used as the fuel source for heating, supplemented with natural gas on an as-needed basis.

Sludge from the secondary digester is pumped to a belt filter press (BFP) for dewatering. Filtrate from the BFP is fed back to the headworks of the plant. Dewatered sludge is moved by conveyor from the BFP to the compost facility. The compost facility is a batch feed facility. Wood chips are added to the sludge as an amendment material prior to composting. Three local businesses are contracted to purchase the compost produced by the WWTP for use as a soil conditioner in agricultural and horticultural activities.

Performance History

The average-day flow to the Marsh Creek WWTP between January 1995 and May 1996 was 3.35 mgd. There is a pronounced seasonal variation in flow, with low flows occurring during the dry weather period of June to September. The minimum and maximum day flows for the period were 1.75 and 12 mgd, respectively. The hydraulic peaking factor was over 4.0. This high value indicates an inflow and infiltration problem within the collection system.

The average BOD_5 and TSS concentrations in the raw sewage flow to the WWTP for January 1995 to May 1996 were 228 and 176 mg/L, respectively. The BOD_5 concentration was reasonably consistent over the period of record, but the TSS concentration fluctuated widely. The high BOD_5 and the TSS concentrations can be attributed to the introduction of leachate and hauled waste to the raw sewage at the headworks of the plant as well as sewage from local food processing plants. The average ortho phosphate (PO_4) concentration of the raw sewage between January 1995 and May 1996 was 2.7 mg/L. The average BOD_5 and TSS loads to the plant were 6,032 lb/day and 4,908 lb/day, respectively.

The average final effluent concentrations for BOD_5, TSS, and PO_4 were 22 mg/L, 10 mg/L, and 0.4 mg/L, respectively. The average concentrations for BOD_5 and TSS are below the discharge criteria of 30 mg/L for both parameters. The average removal efficiencies were 90 percent, 90 percent, and 82 percent for BOD_5, TSS, and PO_4, respectively.

The average MLSS concentration for the aeration basins at the Marsh Creek WWTP from January 1995 to May 1996 was 2,275 mg/L. The average solids residence time (SRT) for the WWTP was 3.9 days. The SRT was less than 6 days for over 95 percent of the time. The average food to microorganism (F/Mv) ratio, based on the ratio of BOD_5 loading to the aeration basin and the mixed liquor volatile suspended solids (MLVSS) concentration, was 0.31 day^{-1}.

The RAS flow rate for the Marsh Creek WWTP is controlled by two single-speed pumps, each rated for a capacity of 1 mgd. The flow is not measured but can be controlled by adjusting the pump speed setting.

The average SVI was 84 mL/g. The low SVI indicated a very well-settling sludge.

The percentages of total dry solids that were volatile for both the raw and digested sludge were 69 percent and 55 percent, respectively. The volatile destruction in the primary digester was 45 percent. The average hydraulic residence time (HRT) of the primary digester was 42 days.

The BFP is used to dewater the digested sludge prior to composting. The average percentage of solids of the digested sludge feed to and from the BFP was 2.95 percent and 21 percent, respectively.

The average monthly electrical usage for the Marsh Creek WWTP was 124,235 kWh between January 1995 and May 1996. There appeared to be a trend of increasing electrical usage by the WWTP over the 15-month period. This was likely due to increased influent flow and increased organic load to the aeration basin.

Field Test

The Marsh Creek WWTP field test program was conducted from May 28 to June 28, 1996. Table 2-8 presents a comparison between the unit process loadings and effluent quality during the field test program and historical values for the facility. The unit process loadings were similar to historical values.

Field testing consisted of offline sampling, online monitoring, and performance testing of specific equipment and processes. The offline sampling results were based on 24-hr composite samples and grab samples taken at various points in the process. The online data consists of data from permanent plant monitoring equipment supplemented with temporary instruments. The following parameters were measured using permanent instrumentation: plant flow, RAS flow, WAS flow, and air flow. The temporary instruments included DO probes and an MLSS probe in the aeration basins. Performance testing included oxygen transfer efficiency testing of the aeration equipment and a

TABLE 2-8 MARSH CREEK WWTP - SUMMARY OF UNIT PROCESS LOADING DURING FIELD TEST PROGRAM					
Unit Process	**Units**	**Field Test**		**Historical**	
		Average	**Maximum**	**Average**	**Maximum**
Loading					
Hydraulic	Mgd	3.63	12.64	3.35	12
Organic					
BOD_5	lb/d	6,015	NA	6,032	9,762[a]
	mg/L	199	282		
TSS	lb/d	7,255	NA	4,908	13,026[a]
	mg/L	240	425		
Primary Clarifier (1,414 ft^2)					
Surface overflow rate	Gpd/ft^2	2,567	8,939	2,369	8,486
Aeration Basin (200,520 ft^3)					
BOD_5 loading rate	lb/d per 1,000 ft^3	17.0	33.5	18.7	
MLSS concentration	mg/L	1,942	2,340	2,275	
Secondary Clarifiers (1,414 ft^2)					
Surface overflow rate	Gpd/ft^2	2,567	8,939	2,369	8,486
Solids loading rate	lb/h per ft^2	2.7	3.9	1.9	6.7
Belt Filter Press					
Solids concentration in	%	2.7	2.9		
Solids concentration out	%	23.2	21		

Note:
Maximum values are 95th percentile values from historical review.

tracer test on the primary digester. Table 2-9 presents a summary of the field test activities. Detailed test descriptions and results are presented in the Marsh Creek WWTP Site Report (CH2M HILL, 1998d).

The major conclusions from the field study of the Marsh Creek WWTP were:

- The organic loading to the Marsh Creek WWTP was highly variable. This was likely the result of the hauled leachate and industrial wastewater received at the site.

- The increase in organic loading that started Monday mornings had a negative impact on the DO concentration in the aeration basins. The DO was less than 1.0 mg/L for most of the day and recovered at night and on the weekends. BOD

TABLE 2-9 MARSH CREEK WWTP - FIELD TEST PROGRAM			
Offline Sampling			
Sample Location	**Frequency**	**Type of Sample**	**Analysis**
Raw sewage	Daily	24 h	$CBOD_5$, TSS, VSS, TP
Primary effluent	Daily	24 h	$CBOD_5$, NH_3-N, TSS, VSS, TP
Secondary effluent	Daily	24 h	$CBOD_5$, TKN, TSS, TP, NO_3-N, NO_2-N, NH_3-N
Gravity thickener inf. & eff.	1/week	grab	TS/TSS, VSS
Gravity thickener recycle	1/week	grab	$CBOD_5$, TS/TSS, TP, TKN
Belt press in & out	1/week	grab	TS
BFP filtrate	1/week	grab	TKN, TP, $cBOD_5$, TSS, NH_3-N
MLSS	2/week	grab	TSS, VSS
RAS	2/week	grab	TSS
Leachate	NA	grab	$CBOD_5$, NH_3-N, TSS, VSS
Online Monitoring Program			
Location	**Type**	**Data**	
Raw sewage	Flow	1 existing meter - magmeter	
RAS	Flow	2 existing meters - magmeter	
WAS	Flow	1 existing meter - magmeter	
Air	Flow	1 existing meter - orifice plate	
Aeration basin	Dissolved oxygen Solids (MLSS)	5 temporary meters 1 temporary meter	
Performance Testing			
Location	**Type**	**Analysis**	
Aeration basin	Offgas	Oxygen transfer efficiency	
Digester	Tracer	Mixing	

breakthrough occurred occasionally. Final effluent concentrations were greater than 60 mg/L.

- The measured standard oxygen transfer efficiency (SOTE: 20°C, 0 mg/L DO) of the membrane panel aeration system was 18 percent.

- Marsh Creek WWTP provided partial nitrification during the first two weeks of the study period, and almost complete nitrification during the second two weeks. The switch from partial to full nitrification did not have a negative impact on the effluent quality.

- Hydraulic loading increased rapidly during storm events, from an average of 3.35 mgd to 12 mgd. However, the sudden increase in flow did not have a negative impact on the TSS concentration in the final effluent.

- The digester provided 45 percent volatile solids destruction. The level of volatile destruction was lower than expected. Expected reduction in volatile solids was between 50 and 55 percent. This may have been the result of poor mixing in the digester.

- The measured active volume of the primary digester was 79 percent of the total volume available. Approximately 6 percent of the pumped sludge short-circuited the digester volume.

ARLINGTON SEWAGE TREATMENT PLANT

Figure 2-4 presents a flow schematic and Table 2-10 summarizes the unit processes of the Arlington sewage treatment plant (STP). Wastewater, consisting mainly of domestic, institutional, and commercial sewage, flows by gravity to the STP. The design capacity of the STP is 4.0 mgd and the current average-day flow is 3.44 mgd. The discharge criteria for the facility are 30 mg/L BOD_5 and 30 mg/L TSS. The plant does not have an ammonia removal requirement. However, operators are required to measure the ammonia concentration and include the result as part of the monthly summary report to the NYSDEC.

The wastewater flows by gravity through a coarse bar screen to the aerated grit chamber and comminutor. The screenings and grit are transported to a landfill. The degritted sewage flows by gravity to a primary clarifier distribution chamber. Supernatant from sludge thickeners and filtrate from the BFP are combined with the raw sewage and the combined flow is distributed to four primary clarifiers. The primary sludge is pumped from the primary clarifiers to the gravity thickeners.

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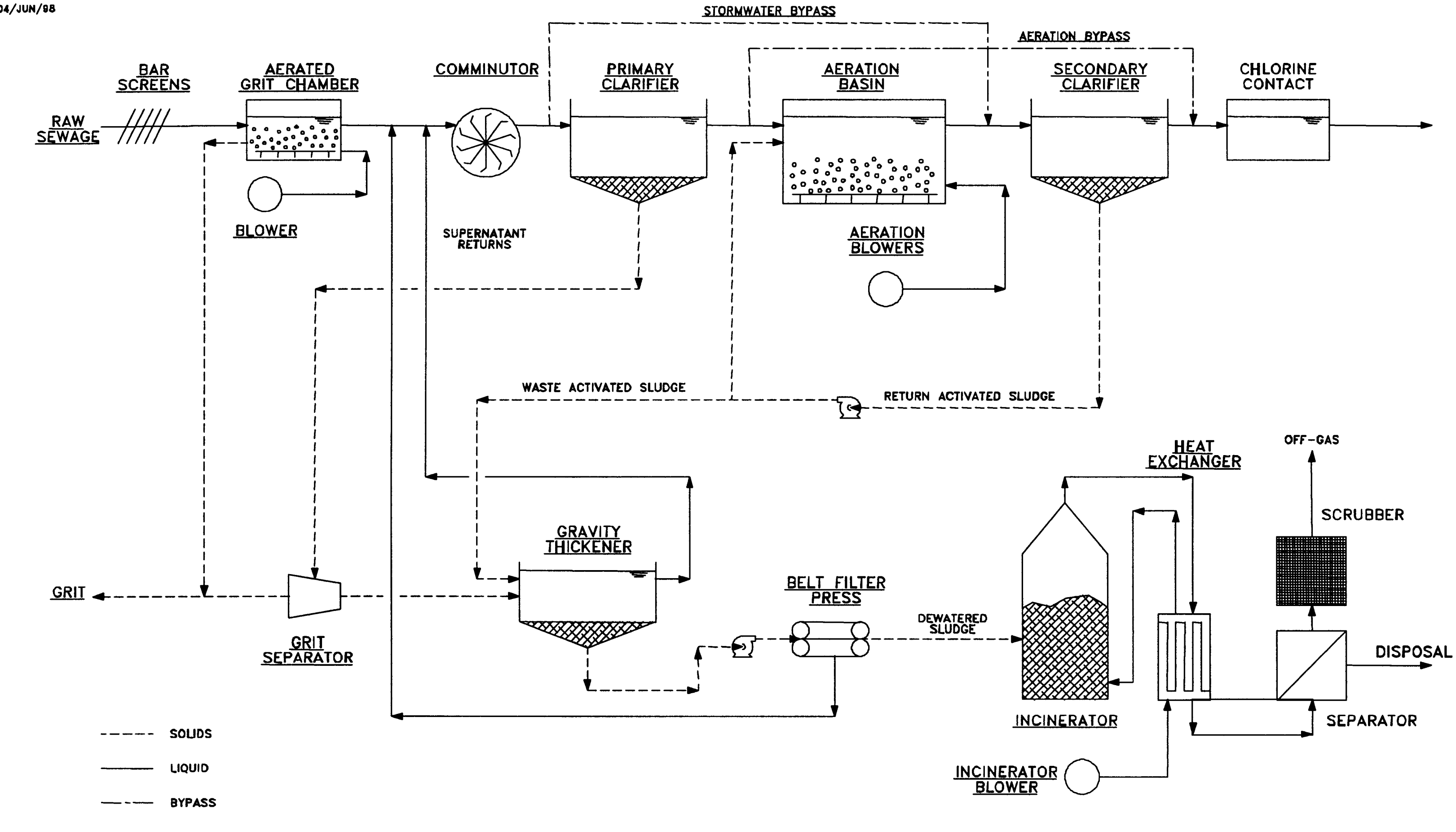

FIGURE 2-4
ARLINGTON STP
PROCESS FLOW SCHEMATIC

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TABLE 2-10 ARLINGTON STP – SUMMARY OF UNIT PROCESSES		
Unit Process	**Number**	**Description**
Bar screen	2	Mechanical clean
Grit chamber	1	Aerated with dedicated blower
Primary clarifier	2 2	Area = 2,088 ft^2 (per unit) 116 ft x 18 ft; 8.67 ft deep Area = 891 ft^2 (per unit) 49.5 ft x 18 ft; 8.33 ft deep
Aeration basin	3 (2 in service)	Area = 3,942 ft^2 (per unit) Volume = 45,176 ft^3 (per unit) Depth = 12 ft
Diffusers		Coarse bubble Area per diffuser = 14 ft^2 Number per tank = 280 Submergence = 11.5 ft
Aeration equipment blowers	2 1	60 hp Positive displacement, variable speed drive 60 hp Positive displacement, split ring drive
Secondary clarifier	3	Area = 2,088 ft^2 (per unit) 116 ft x 18 ft; 8.67 ft deep
Chlorine contact chamber	3	Area = 695 ft^2 (per unit) Volume = 4,517 ft^3 (per unit)
Gravity thickener	2	Volume = 5,772 ft^3 (per unit) Dia. = 26 ft; depth = 10 ft
Belt filter press	1	Width = 1 m
Incinerator	1	Fluidized bed 800 lb/hr dry solids

The primary clarifier effluent is recombined in a common primary effluent channel that connects the three aeration basins. Under loading conditions prior to and during the test, two of the three aeration basins were in service. The aeration basins can be operated as plug-flow or step-feed basins.

Air is provided to the aeration basins by three positive displacement blowers. Two of the three blowers have variable-frequency drive systems, and the third blower has a manually operated split disk drive system. The Arlington STP has an automatic DO control system, which operates the blowers based on the DO measurement in the aeration basin.

The Arlington STP has three rectangular secondary clarifiers. There is an approximately 10-foot hydraulic drop between the aeration basins and the secondary clarifiers. In the past, air entrainment due to the free-fall discharge and turbulence in the aeration basin discharge channel was a problem. The operators use an automated valve to control the water surface level in the aeration basin discharge channel to ensure that the aeration basin outfall remains flooded and the pipe to the secondary clarifier is submerged at all times.

The RAS is pumped from the secondary clarifier to the head of the aeration basin. Two RAS pumps service three clarifiers. The RAS is measured with magnetic flow meters located at the entrance to each aeration basin. Sludge is wasted from the RAS line using a manually operated bypass valve located on the combined RAS line. The WAS is combined with the primary sludge in the gravity thickeners.

The secondary effluent flows by gravity through the chlorine contact chamber and to final discharge in the Hudson River.

The Arlington STP has two bypass systems, the stormwater bypass and the secondary bypass. The stormwater bypass uses an overflow weir to divert raw sewage from the primary clarifier distribution chamber to the inlet channel for the secondary clarifiers. The secondary bypass uses an overflow weir to divert primary effluent from the aeration basin inlet channel to the chlorine contact chamber. During a storm event, flows in excess of 4.5 mgd receive primary clarification and disinfection only, and flows in excess of 6.0 mgd receive secondary clarification and chlorination only. The maximum flow to the Arlington STP is 8.0 mgd. Therefore, the maximum flow to the primary clarifiers is 6.0 mgd, the maximum flow to the aeration basins is 4.5 mgd, and the maximum flow to the secondary clarifiers is 6.5 mgd (4.5 mgd from the aeration basin and 2.0 mgd from the stormwater bypass).

Solids from the primary clarifiers are pumped to the gravity thickener for co-thickening with the WAS. The thickened sludge is then pumped to the BFP and into the sludge incinerator. Since February 1996, the BFP and sludge incinerator have operated for approximately six hours every day (during the evening shift). Prior to this date, the belt press and incinerator operated approximately once per week.

Performance History

The average-day flow to the Arlington STP was 3.45 mgd between January 1995 and June 1996, and the maximum instantaneous flow recorded was 8.9 mgd. Therefore, the hydraulic peak factor is approximately 2.5 for the period of record.

The TSS and BOD_5 concentrations in the raw sewage flow to the Arlington STP for January 1995 to June 1996 were 124 and 130 mg/L, respectively. The average TSS and BOD_5 loadings to the treatment plant were 3,542 and 3,674 lb/day, respectively.

The average TSS and BOD_5 concentrations in the final effluent from the Arlington STP from January 1995 to June 1996 were 7.5 and 6.7 mg/L, respectively. This is well below the effluent discharge requirement of 30 mg/L for each parameter. The average BOD_5 and TSS removal efficiency for the facility was 94 percent. The Arlington STP provides a good standard of treatment. The BOD_5 and TSS removal efficiencies were greater than 90 percent approximately 80 percent of the time between January 1995 and June 1996.

The average MLSS concentration in the two aeration basins in service was 1,050 mg/L. The MLSS concentration was significantly lower in the warmer period (wastewater temperature) of June through October. During this time, operators have reduced the solids inventory in the aeration basin by reducing the MLSS concentration in an attempt to prevent nitrification. The average MLSS concentration for the months of November through June was 1,150 mg/L; the average MLSS concentration for the months of July through October was 720 mg/L.

The F/Mv ratio for the Arlington STP during the 18-month period was 0.65 day^{-1}. The F/Mv ratio was very high in September and October 1995 due to the low MLSS concentration in the aeration basin at the time. The SRT for the plant from January 1995 to June 1996 was 4.9 days. Other than on a few days, the SRT remained below six days for the period of record.

The average solids concentrations for the thickened and dewatered sludge from January 1995 to December 1995 were 3.6 and 20.6 percent dry solids, respectively. Starting in February 1996, the Arlington STP operated the dewatering and incineration process every day during the evening shift. Prior to February, the dewatering and incineration process was operated once a week for approximately 36 hours. The change in operation resulted in an increase in the dewatered sludge solids concentration from 20.6 percent dry solids in 1995 to 25.6 percent dry solids in July 1996. The solids concentration in the dewatered sludge had a significant impact on the fuel consumption in the incineration process.

The average electrical consumption for the Arlington STP from December 1993 to June 1996 was 5,270 kWh/day. The average oil consumption from January 1995 to June 1996 was 180 gallons per day. The fuel oil was primarily used for the sludge incineration process. The average oil consumption per pound of solids processed was 65 gallons/lb during 1995 and 12 gallons/lb in July and August 1996. As noted above, the incinerator oil consumption was influenced by the solids concentration in the dewatered sludge.

Field Test

The Arlington STP field test program was conducted from July 17 to August 25, 1996. Table 2-11 presents a comparison between the unit process loadings and effluent quality during the field test program and historical values for the facility. The hydraulic and organic loadings to the treatment plant were similar to the historical values.

Field testing consisted of offline sampling, online monitoring, and performance testing of specific equipment and processes. The offline sample results were based on 24-hour composite samples and grab samples taken at various points in the process. The online data consists of data measured from temporary instruments installed for the test period and the existing online metering equipment at the site. The temporary instruments included DO meters installed in the aeration basin, solids concentration meters in the aeration basin, and solids concentration meters in the final effluent. Plant metering was used to monitor raw sewage flow, RAS flow, WAS flow, and total air flow. The performance testing consisted of oxygen transfer efficiency testing of the existing aeration equipment, and "wire to water" performance testing of the aeration blowers, incinerator fan, and the RAS pumps. Table 2-12 summarizes the work done. Detailed descriptions and results are presented in the Arlington STP Site Report (CH2M HILL, 1998a).

The main conclusions from the field study period for the Arlington STP were:

- The primary clarifiers performed well. The average BOD_5 and TSS removal efficiencies were 47 percent and 65 percent, respectively. Typical BOD_5 and TSS removal efficiencies for primary clarifiers are 35 and 65 percent, respectively.

TABLE 2-11 ARLINGTON STP - SUMMARY OF UNIT PROCESS LOADING DURING FIELD TEST PROGRAM					
Unit Process	**Units**	**Field Test**		**Historical**	
		Average	**Maximum**	**Average**	**Maximum**
Loading					
Hydraulic	Mgd	3.44	6.10	3.45	8.9
Organic					
BOD_5	mg/L	117	179		
	lb/d	3,256	4,696	3,675	4,777
TSS	mg/L	153	250		
	lb/d	4,248	6,215	3,542	5,366
Effluent Quality					
BOD_5	Mg/L	7.6	41	6.7	
TSS	mg/L	10	34	7.5	
Primary Clarifier					
Surface overflow rate	gpd/ft^2	577	1,024	579	1,007
Aeration Basin					
BOD_5 loading rate	lb/d 1,000 ft^3	18.8	27.5	29.4	38.7
HRT	hour	4.7	3.6	4.7	3.6
MLSS concentration	mg/L	856	1150	1050	
Secondary Clarifiers					
Surface overflow rate	gpd/ft^2	549	718	550	1,040
Solids loading rate	lb/h per ft^2	0.24	0.34	0.31	0.46
Chlorine Contact Chamber					
Hydraulic residence time	min	42	24	42	16

Notes:
Maximum loading based on 95th percentile.
Bypass of raw sewage to secondary clarifiers did not occur during the study period. Therefore, the maximum flow to the secondary clarifier was 4.5 mgd.

- The measured standard oxygen transfer efficiency (SOTE: 20°C, 0 mg/L DO) of the existing aeration equipment was 6 percent. The existing aeration system was not able to meet the combined carbonaceous and nitrogenous oxygen demand. The Arlington STP was not able to control (limit) nitrification during the summer months, resulting in low DO concentrations in the aeration basin for extended periods of time.

- The operators shut off the aeration blowers for 2 hours every day in an attempt to reduce the oxygen demand in the basin. This resulted in an anoxic zone develop-

TABLE 2-12
ARLINGTON STP - FIELD TEST PROGRAM

Offline Sampling Program			
Sample Location	**Frequency**	**Type of Sample**	**Analysis**
Raw sewage	daily	24 h	$cBOD_5$, COD, TSS, VSS, TP
Primary effluent	daily	24 h	$cBOD_5$, COD, NH_3-N, TKN, TSS, VSS, TSS
Secondary effluent	daily	24 h	$cBOD_5$, COD, NH_3-N, TKN, TP, TSS, VSS
MLSS	daily	grab	TSS, VSS
RAS	2/week	grab	TSS
Sludge	1/week		
Primary sludge		grab/comp	TS,VS
Thickener in		grab	TS
Thickener out		grab	TS
Belt press out		grab	TS
Recycle	1/week		
Thickener super.		grab	$cBOD_5$, COD, TSS, TP, TKN
Belt press filtrate		grab	$cBOD_5$, COD, TSS, TP, TKN
Additional analysis			
Dewatered sludge		grab	Btu, Ultimate
MLSS		grab	Microbial identification

Online Monitoring Program		
Location	**Type**	**Data**
Raw sewage	Flow	1 existing meter - flume
Aeration basin	Dissolved oxygen	5 temporary meters
RAS	Flow	2 existing meters - magmeter
WAS	Flow	1 existing meter - magmeter
Air	Flow	2 existing meters - orifice plate
Effluent	Suspended solids	1 temporary meter

Performance Testing		
Location	**Type**	**Analysis**
Aeration equipment	Offgas	Oxygen transfer efficiency
RAS pumps	Performance	"Wire to water" efficiency
Aeration blowers	Performance	"Wire to water" efficiency
Incinerator blowers	Performance	"Wire to water" efficiency

ing in the basin, which decreased the overall oxygen demand. However, the anoxic zone was erratic and the online DO data indicated a problem with air distribution once the blowers were returned to service.

- The Arlington STP experienced periodic blooms of filamentous microorganisms, which resulted in poorly settling sludge and foam problems. The filamentous organisms were primarily Nocardia, which are usually associated with low F/Mv ratio, high solids residence time (SRT), and low DO concentrations.

- The secondary clarifiers performed well except during periods of process upsets. The effluent suspended solids concentration was significantly impacted by high flows during storm events.

- The average concentration of the dewatered sludge was 24.1 percent. The belt press operation improved significantly after a change in operational procedures whereby the incinerator was operated once per day rather than once per week.

- The incinerator operated at 200 percent excess air. The incinerator feed rate was determined by the speed of the dewatering process

BERGEN POINT WWTP

Figure 2-5 presents a flow schematic and Table 2-13 summarizes the unit processes of the Bergen Point WWTP facility. The wastewater, consisting mainly of domestic and commercial sewage with very little industrial contribution, flows by gravity to the raw pump station wet well. The design capacity for the WWTP is 30 mgd, and the current average-day flow is approximately 25 mgd. The final effluent discharge requirement for the plant is a monthly average BOD_5 and TSS concentration of 30 mg/L for each parameter.

Wastewater passes through three mechanically cleaned bar screens and is pumped by five variable-speed-drive (VSD) raw sewage pumps to two aerated grit chambers. Degritted wastewater flows to four primary clarifiers. Once settled, the primary sludge is pumped from the bottom of the primary clarifier to the sludge blending tank.

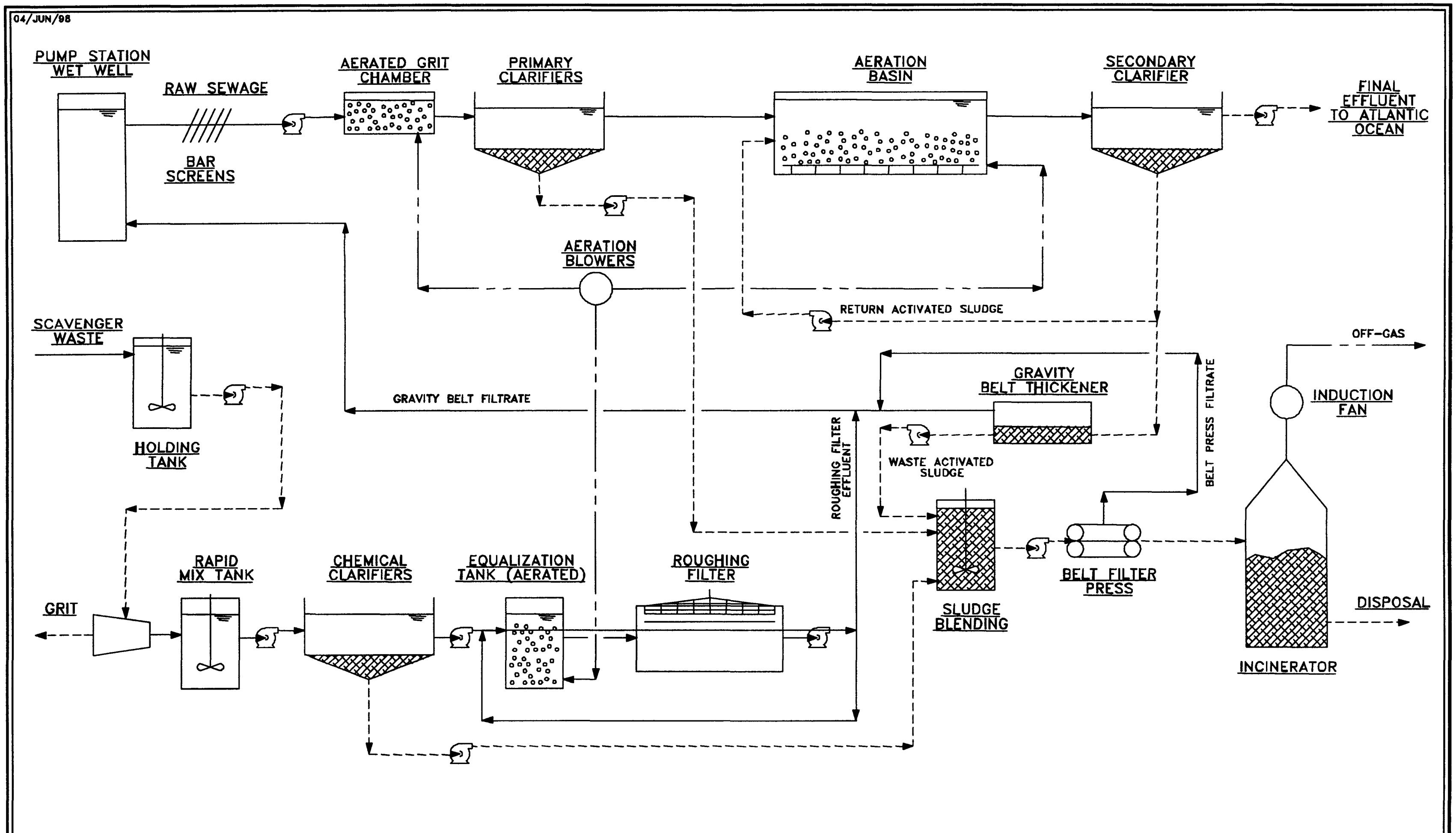


FIGURE 2-5
BERGEN POINT W.W.T.P.
PROCESS FLOW SCHEMATIC

TABLE 2-13
BERGEN POINT WWTP - SUMMARY OF UNIT PROCESSES

Unit Process	Number	Description
Bar screen	3	Mechanically clean
Primary clarifier	4	Area = 6,400 ft^2 (per unit) SWD = 10 ft
Aeration basin (operated in step feed)	8	Area = 10,990 ft^2 (per tank) Volume = 164,800 ft^3 (per tank)
Aeration equipment blowers (centrifugal)	3	1,750 hp (per unit) 25,000 scfm (per unit)
Secondary clarifier (circular)	4 2 (new)	Volume = 114,040 ft^3 (per unit) SWD=12 ft; dia. = 110 ft Volume = 230,900 ft^3 SWD = 15 ft; dia. = 140 ft
Sludge blending tank	1	Volume = 250,000 gallons
Roughing filter	1	Volume = 23,500 ft^3 SWD = 12 ft; dia. = 50 ft
Belt filter press	4	Width = 6.56 feet
Incinerator	2	Multiple hearth - 7 hearth Diameter = 18.5 ft

The primary effluent flows to eight single-pass aeration basins. Under normal loading conditions, six of the eight aeration basins are in service. The aeration basins operate in a step-feed mode, whereby the primary effluent enters the tank at several points along the length of the aeration tank.

Air is provided to the aeration basins by three 1,750-hp centrifugal blowers. Since late 1993, the Bergen Point WWTP has been upgrading its existing coarse-bubble diffusion system to a membrane panel fine-bubble system. The new fine-bubble aeration system will use the DO concentration level in the aeration tanks to control the amount of air being supplied to each section of the tanks. With this upgrade, the plant operators hope to supply the air demand with only one blower.

Aeration tank effluent flows to the secondary clarifier distribution channel, where it is distributed to four 110-ft-diameter circular clarifiers. Two additional secondary clarifiers are under construction. The RAS is pumped to the aeration tank influent. The WAS is thickened using gravity belt thickeners and then pumped to the sludge blending tanks, where it is mixed with the primary sludge and scavenger waste sludge (see below). The underflow is returned to the underdrain system, to eventually be returned to the head of the plant for further treatment.

Sodium hypochlorite (NaOCl) is added to the clarifier effluent for disinfection prior to final discharge. There are no disinfection contact tanks; contact time is provided in the 5.5-mile-long outfall pipe, which discharges to the Atlantic Ocean. Under high-tide conditions and storm events, the final effluent is pumped by three 500-hp VSD effluent pumps.

The Bergen Point WWTP receives approximately 500,000 gallons per day of scavenger waste consisting of septage, sludge from smaller WWTPs in the area, high-strength industrial wastewater, and other miscellaneous liquid waste products. The scavenger waste is pumped from the holding tanks through the cyclone degritters and rapid mixing box to a chemical sludge holding tank for gravity separation. The chemical sludge is pumped to the sludge blending tank along with the primary sludge and WAS. The overflow is treated by a roughing filter to reduce organic loading to the plant process. The roughing filter effluent is returned to the head of the plant via the underdrain system.

The combined sludge is pumped from the sludge blending tanks to four BFPs for dewatering. The dewatered sludge is incinerated in two multiple-hearth furnaces. Typically, one incinerator operates continuously while the other incinerator is out of service for maintenance. With one incinerator in service, there is not sufficient capacity to handle the sludge generated at the site. Excess sludge is transported offsite for landfill disposal.

<u>Performance History</u>

The average flow including the scavenger waste liquid stream entering the Bergen Point WWTP from January 1995 to September 1996 was 25 mgd. The maximum day flow recorded between January 1995 and September 1996 was 32 mgd. Therefore, the hydraulic peak factor for the Bergen Point WWTP is 1.3, which is very low for a municipal WWTP.

The average TSS and BOD_5 concentrations in the combined raw and scavenger waste flows for the period of January 1995 to August 1996 were 278 and 248 mg/L, respectively. The average TSS and BOD_5 loadings to the treatment plant were 56,200 and 51,000 lb/day, respectively. The scavenger waste facility provided an average BOD_5 of 14,850 lb/day, which was approximately 30 percent of the total BOD_5 loading to the treatment facility.

The average TSS and BOD_5 concentrations in the final effluent from the Bergen Point WWTP from January 1995 to September 1996 were 13 and 24 mg/L, respectively. This is well within the plant's monthly average effluent discharge requirement of 30 mg/L for TSS and 30 mg/L for BOD_5. The average TSS and BOD_5 removal efficiencies were 94 percent and 90 percent, respectively. The TSS and BOD_5 removal efficiencies were greater than 85 percent 92 and 86 percent of the time, respectively. The average MLSS concentration over the 21-month period was 1,690 mg/L.

The average F/Mv ratio for the Bergen Point WWTP was 0.3 day^{-1}. Typically, the F/Mv ratio is between 0.3 and 0.5 day^{-1} for conventional activated sludge without nitrification. The average RAS flow rate was 9.7 mgd, or 40 percent of the total flow.

The average SVI for the mixed liquor at the Bergen Point WWTP was 110 mL/g. Typical SVI values for activated sludge are between 120 and 150 mL/g. SVI values greater than 200 mL/g are considered poorly settling sludges. The SVI at the Bergen Point WWTP was greater than 200 mL/g only 2 percent of the time during the 21-month historical performance period. The average SRT for the Bergen Point WWTP was 6.5 days. The net yield of a biological system [kg of volatile suspended solids (VSS) produced per kg of BOD_5 removed] was estimated to be 0.56 mg VSS/mg BOD_5 removed.

The average solids concentrations for the thickened and dewatered sludge from January 1995 to December 1995 were 3.0 and 26.5 percent dry solids, respectively. Solids concentration in the dewatered sludge should have a significant impact on the fuel consumption in the incineration process. Typically, a combined primary and activated sludge requires a solids concentration greater than 30 percent for a self-sustaining incineration process.

Field Test

The Bergen Point WWTP field test program was conducted from September 9, 1996, to October 27, 1996. Table 2-14 presents a comparison between the unit process loadings and effluent quality during the field test program and the historical values for the facility. The hydraulic loading to the facility was very similar to the historical values. However, the organic loading during the field test was approximately 30 to 35 percent less than the loading from the historical data reviewed. The difference was likely the result of the use of a roughing filter as a pretreatment for the scavenger waste. The roughing filter was brought into operation in the early part of 1996. The historical data reviewed was from January 1995 to September 1996.

TABLE 2-14 BERGEN POINT WWTP - SUMMARY OF UNIT PROCESS LOADING DURING FIELD TEST PROGRAM					
Unit Process	**Units**	**Field Test**		**Historical**	
		Average	**Maximum**	**Average**	**Maximum**
Loading					
Hydraulic	mgd	26	34	25	32
Organic					
BOD_5	lb/d	35,579	52,831	51,033	80,840
TSS	lb/d	42,040	67,035	56,200	116,900
Effluent Quality					
BOD_5	mg/L	13.2	26	24	
TSS	mg/L	11.9	28	13	
Primary Clarifier					
Surface overflow rate	gpd/ft^2	1,010	1,320	977	1,250
Aeration Basin					
(6 basins in service)					
BOD loading rate	lb/d 1,000 ft^3	21.4	31.4	29.3	45.5
HRT	hours	6.9	5.3	9.5	7.4
MLSS concentration	mg/L	1,414	--	1,609	2,960
SVI	ml/g	–	--	110	197
SRT	day	3.7	--	6.5	
F/Mv ratio	day^{-1}	0.27	0.45	0.3	0.52
Secondary Clarifier					
Surface overflow rate	gdp/ft^2	680	889	658	842
Solids loading rate	lb/h per ft^2			0.5	1.0
Trickling Filter					
BOD_5 loading	lb/d 1,000 ft^3	276	1,059	NA	NA

Field testing consisted of offline sampling, online monitoring, and performance testing of specific equipment and processes. The offline sample results were based on 24-hour composite samples and grab samples taken at various points in the process. The online data consists of data measured from the existing online metering equipment at the site. The performance testing consisted of oxygen transfer efficiency testing of the existing aeration equipment and "wire to water" efficiency testing of the aeration blowers, raw sewage, and RAS pumps. Table 2-15 summarizes the work done. Detailed test descriptions and results are presented in the Bergen Point WWTP Site Report (CH2M HILL, 1998b).

TABLE 2-15
BERGEN POINT WWTP - FIELD TEST PROGRAM

Offline Sampling Program

Sample Location	Frequency	Type of Sample	Analysis
Primary influent	Daily	24 h	$cBOD_5$, COD, TSS, VSS
Primary effluent	Daily	24 h	$cBOD_5$, COD, NH_3-N, TKN, TSS, VSS
Secondary effluent	Daily	24 h	$cBOD_5$, COD, NH_3-N, TKN, TSS, VSS
MLSS	Daily	grab	TSS, VSS
RAS	Daily	grab	TSS
Sludge			
Gravity belt thickener out	1/wk	grab	TS
Belt filter press in	daily	grab	TS
Belt filter press out	daily	grab	TS
Recycle			
Gravity belt filtrate	1/wk	24 h	$cBOD_5$, TKN, TSS
Belt press filtrate	1/wk	8 h	$cBOD_5$, TKN, TSS
Roughing filter			
Influent	2/wk	24 h	$cBOD_5$, COD, NH_3-N, TKN, TSS, VSS, $sBOD_5$
Effluent	2/wk	24 h	$cBOD_5$, COD, NH_3-N, TKN, TSS, VSS, $sBOD_5$

Online Monitoring Program

Location	Type	Data
Raw sewage	Flow	1 existing meter - magmeter
Aeration basin	Flow	8 existing meters (1 per basin) - magmeter
	Dissolved oxygen	12 existing meters (1 per basin, plus 4 along one basin)
Air supply	Flow	9 existing meters (1 basin plus total)
Incinerator	Temperature	7 existing meters - thermocouple
Flue gas	Temperature	4 existing meters
	Oxygen	1 existing meter
Trickling filter	Flow	6 existing meters
Sludge	Flow	Totalized volume of sludge per day

Performance Testing

Location	Type	Analysis
Aeration equipment	Offgas	Oxygen transfer efficiency
Blowers	Performance	"Wire to water" efficiency
Raw sewage pumps	Performance	"Wire to water" efficiency
RAS pumps	Performance	"Wire to water" efficiency

The main conclusions from the field study of the Bergen Point WWTP were:

- The performance of the primary clarifiers was lower than expected. However, the poor performance was not due to hydraulic overloading. It was likely the result of the settling characteristics of the raw sewage solids.

- The activated sludge system provided good performance with only six basins in service. The effluent quality was well below the effluent discharge criteria throughout the test period.

- The roughing filter performed as expected for BOD_5 removal. However, the COD removal was very high. This indicated that the COD removal was likely due to volatilization. The compounds being removed should be identified to determine if any health and safety concerns are associated with this process.

- The gravity belt thickener and belt presses performed well. The average TS concentrations from the thickener and belt presses were 3.5 and 26.4 percent solids, respectively.

- The incinerator experienced frequent short-term increases in temperature (flareups), which resulted in clinker formation in the incinerator body. The WWTP typically operated with only one incinerator in service, with the second incinerator out of service for maintenance. Reducing flareups by improving control over the sludge feed would reduce the operating and maintenance costs of this process.

- The measured standard oxygen transfer efficiency (SOTE: 20°C, 0 mg/L DO) of the new membrane panel aeration equipment was between 16 and 17 percent. The measured SOTE of the old coarse-bubble diffusers was 6.5 percent. The upgrade from coarse- to fine-bubble aeration should result in a net decrease of approximately 60 percent in the air required to meet the oxygen demand in the aeration basin.

- The rated capacity of the existing blowers was greater than the air required to meet the process demands for the site.

- The measured "wire to water" efficiency of the existing aeration blowers was between 54 and 56 percent. This was lower than expected for the blower installation. The expected "wire to water" efficiency for centrifugal blowers is between 70 and 80 percent.

- The measured "wire to water" efficiency of the raw sewage pumps was between 40 and 80 percent, and the measured "wire to water" efficiency of the RAS pumps was between 50 and 65 percent. The efficiency was lower at lower speeds due to the low efficiency of the ampli-speed drive system.

YONKERS JOINT WWTP

Figure 2-6 presents a flow schematic and Table 2-16 summarizes the unit processes of the Yonkers Joint WWTP. The wastewater consists mainly of domestic, institutional, and commercial sewage. Sewage enters the plant via the North Yonkers force main at the north control structure, and from the South Yonkers screen house. The design capacity of the Yonkers Joint WWTP is 92 mgd, and the current measured average day flow is 101 mgd. The discharge criteria for the facility are 30 mg/L BOD_5 and 30 mg/L TSS.

The wastewater flows by gravity through mechanically cleaned bar screens and the collected screenings are trucked offsite to be co-disposed with municipal solid waste. The wastewater then flows to the aerated grit chambers, where grit is removed, dewatered, and trucked to a local landfill. The raw sewage flows by gravity to four primary clarifiers. Once settled, the primary sludge is pumped from the bottom of the primary clarifiers to the primary gravity thickener. Supernatant from the primary gravity thickeners is combined with the raw sewage at the head of the grit chamber effluent channel.

The primary clarifier effluent is measured using a venturi flow meter. Centrifuge centrate (the liquid removed by the centrifuge) is returned at the head of the primary effluent channel. The total flow is controlled by a settled sewage bypass structure that limits the quantity of settled sewage to be passed to the secondary treatment facility to 150 mgd. All diverted quantities in excess of 150 mgd pass directly to the chlorine contact tank.

The primary effluent flows to six four-pass aeration tanks. Under normal loading conditions, four of the six aeration basins are in service. The aeration basins can be operated as either step-feed or

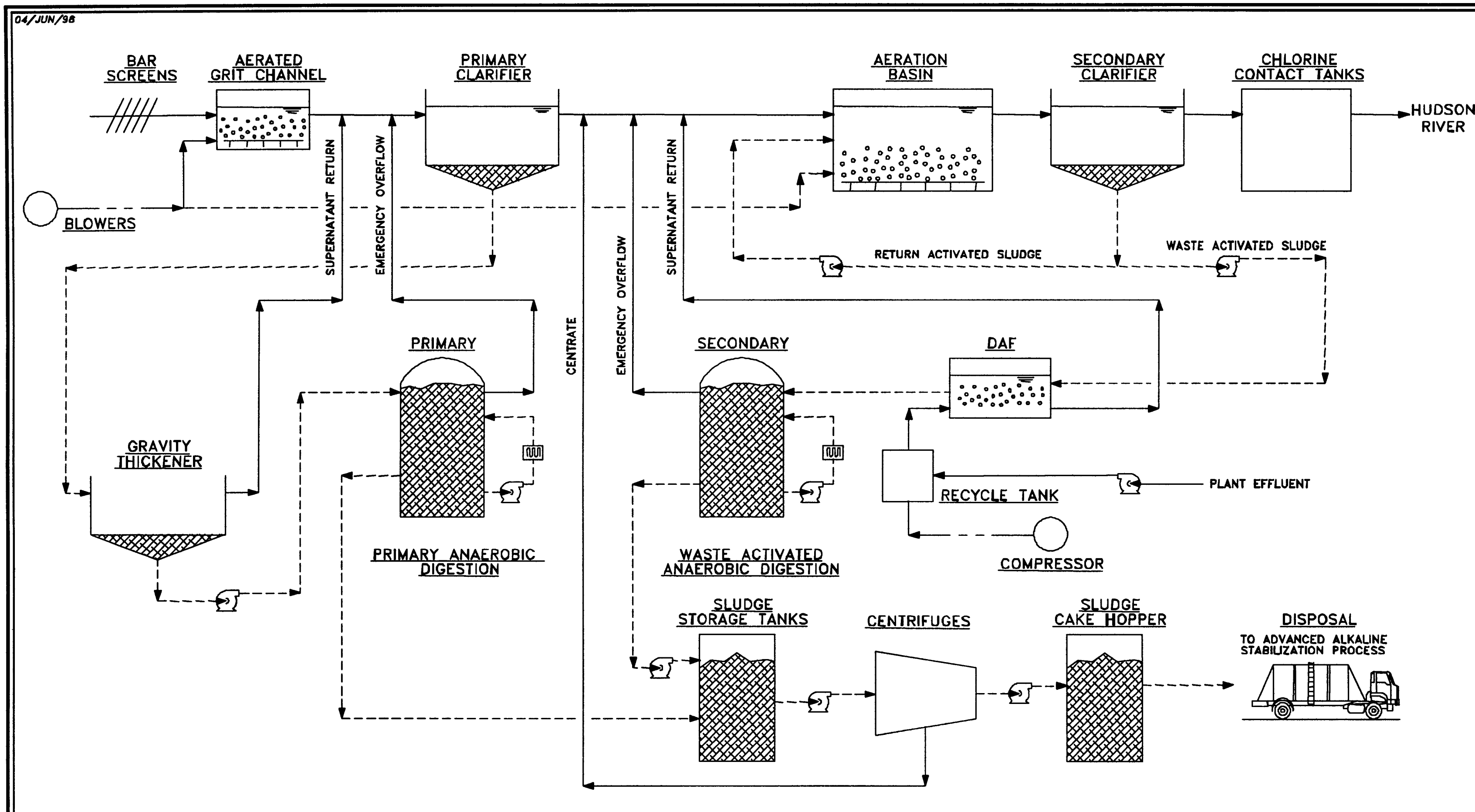


FIGURE 2-6
YONKERS JOINT W.W.T.P.
PROCESS FLOW SCHEMATIC

TABLE 2-16 YONKERS JOINT WWTP - SUMMARY OF UNIT PROCESSES		
Unit Process	**Number**	**Description**
Bar screen	3	Mechanically clean
Aerated grit tanks	3	L = 77; W = 22.5; d = 12' Volume = 155,500 gal.
Primary clarifier	4 (5 channels per tank)	Area = 15,000 ft^2 (per unit) SWD = 12 ft
Aeration basin	6 (4 in service)	Area = 5,700 ft^2 (per unit) Volume = 2.87 mg (per unit)
Aeration equipment blowers	6	1,700 hp (per unit) 35,000 cfm (per unit) 3 electric motors, 3 with dual fuel engines
Secondary clarifier	9	Area = 13,700 ft^2 (per unit) SWD = 11 ft
Chlorine contact chamber	1 1	North tank: Volume = 1.08 mgd South tank: Volume = 0.65 mg
Primary gravity thickener	3	Area= 4,770 ft^2 Dia. = 45 ft
Degritting cyclones	2 (1 in service)	Flow = 1,200 gpm max = 700 gpm min
Primary digester	2 1	70 ft diameter, 119,300 ft^3 volume 56 ft diameter, 76,350 ft^3 volume
Dissolved air floatation thickener	6	Area = 960 ft^2 (per unit)
Secondary digester	6	Volume = 96,000 ft^3 (per unit)
Sludge storage tanks	2	Area = 2,520 ft^2, Volume = 60,400 ft^3
Centrifuge	4	150 gpm (per unit)

plug-flow basins. At the time of the field test, the aeration tanks operated in the plug-flow mode, whereby all the settled sewage was added at the influent of pass one. The plant had three electrically driven and three diesel-engine-driven blowers; two of the electric blowers supplied the air demand for the facility.

Secondary clarification consists of nine rectangular final settling tanks. The Yonkers Joint WWTP has three 1.5- to 5.5-mgd variable-speed RAS pumps per pair of final settling tanks. The WAS is pumped from the sedimentation tanks by four 0.5- to 1.0-mgd variable-speed WAS pumps to the dissolved air flotation units (DAF) for thickening. The secondary effluent flows by gravity to the north and south chlorine contact tanks. The final disinfected effluent is discharged into the Hudson River.

The solids handling at the Yonkers Joint WWTP is treated in two separate systems, the primary solids handling system and the secondary solids handling system. In the primary solids handling system, the primary sludge is passed through cyclone degritters to gravity thickeners where it is thickened and pumped to the primary digester. The thickener overflow is returned to the primary settling tank influent channel downstream of the aerated grit chamber. The primary digestion facilities include three high-rate anaerobic digesters operating in parallel. The final digested sludge overflows from the digester to the sludge storage tanks.

In the secondary solids handling system, the WAS is thickened by six DAF thickeners. Floated sludge is skimmed from the water surface to sludge sumps and is then pumped to the secondary digesters (the WAS digesters). The DAF underflow is removed and returned to the settled sewage channel, upstream of the aeration basins. The WAS digesters comprise six high-rate anaerobic digesters operating in parallel. The digested sludge is transferred to the sludge storage tank where it is mixed with the primary digested sludge.

Prior to December 1991, the stabilized sludge at the Yonkers Joint WWTP was disposed of by barge into the ocean. Since 1992, the digested primary sludge and WAS are combined, then pumped to four solid-bowl centrifuges. The centrate is discharged to the primary effluent channel. The dried sludge cake from the centrifuge is transferred to a series of hoppers. The sludge is loaded into trucks and hauled by contractor to an advanced alkaline stabilization process before being marketed for beneficial reuse.

Performance History

The average-day flow to the Yonkers Joint WWTP from January 1996 to August 1996 was 101 mgd. The average diurnal variation (the difference between the maximum and minimum instantaneous flow, expressed as a percentage of the average daily flow) was 30 percent. The maximum instantaneous flow recorded between January 1996 and August 1996 was 171 mgd. The flow to the plant exceeded 92.0 mgd (rated capacity) approximately 72.5 percent of the time during the 8-month period of record.

The average TSS and BOD_5 concentrations in the raw sewage flow to the Yonkers Joint WWTP for January 1995 to August 1996 were 124 and 121 mg/L, respectively. Typical concentrations for municipal sewage without significant industrial sources are between 100 and 150 mg/L for TSS and BOD_5. The average TSS and BOD_5 loadings to the treatment plant were 89,774 and 87,047 lb/day, respectively.

The average TSS and BOD_5 concentrations in the final effluent from the Yonkers Joint WWTP from January 1995 to August 1996 were 15.3 and 8.4 mg/L, respectively. This is below the monthly average BOD_5 and TSS effluent discharge requirement of 30 mg/L for each parameter. The average TSS and BOD_5 removal efficiencies were 86.8 and 92.4 percent, respectively.

The average MLSS concentration over the 20-month period in the four aeration basins was 2,177 mg/L. From mid-June 1995 to mid-July 1995, the treatment plant experienced high solids concentrations in its aeration basins due to solids handling problems attributed to mechanical breakdown of its dewatering process. For the period from April 1996 to August 1996, when the solids handling at Yonkers Joint WWTP was operating properly, the average MLSS concentration was 1,382 mg/L.

The average F/Mv ratio for the Yonkers Joint WWTP based on the BOD_5 load to the aeration basins and the MLSS concentration was 0.57 day^{-1}. The average SRT for the WWTP from January 1995 to August 1996 was 3.6 days. Plant operation data indicates that SRT values were kept in the range of four to six days until the summer of 1995. The average SVI from January 1995 to August 1996 was 105 mL/g. Typical SVI values for activated sludge are between 120 and 150 mL/g. The Yonkers Joint WWTP has well-settling sludge.

The primary thickened sludge had an average solids concentration of seven percent, and the thickened WAS had an average concentration of 4.6 percent solids over the 12-month period of record. The average concentrations of the primary and secondary digested sludge were 2.5 percent and 3.0 percent solids, respectively. The reduction in solids in the anaerobic digesters (i.e., the difference in solids concentration into the digester and solids concentration out of the digester) was very high for the primary digester. The reduction in solids concentration was partly the result of volatile solids destruction. However, solids deposition within the digester body should increase the reduction in solids observed. The primary digesters at the Yonkers Joint WWTP are susceptible to solids deposition; they require cleaning every three years to remove the deposition of grit and heavy solids that decreases the effective digester volume, therefore reducing digester efficiency.

Based on the solids concentration and the volatile ratio of the sludge into and sludge out of the digester, the volatile solids destruction in the primary and the secondary digesters was 48,487 lb/day (71 percent) and 31,096 lb/day (39 percent), respectively. Gas production for high-rate anaerobic digestion was 15 to 20 cubic feet of gas produced per pound of volatile matter destroyed. Based on these figures, the expected gas production for the primary digester is between 730,000 and 970,000 cubic feet per day, and between 466,000 and 622,000 cubic feet per day for the secondary digester.

The average gas production rates recorded by the plant during the historical study for primary and secondary digesters were 393,000 and 653,000 cubic feet per day, respectively. The secondary digesters at the Yonkers Joint WWTP destroyed volatile matter and produced gas at their expected rates. Based on volatile destruction from historical data, the primary digesters produced only 46 percent of the digester gas that they are theoretically capable of producing. The discrepancy in the historical data could be the result of unreliable gas metering equipment.

The average digested sludge solids concentrations before and after the dewatering process were 3 and 27 percent, respectively.

The average electrical demand for the Yonkers Joint WWTP from January 1995 to December 1995 was 3,878 kWh/day. The electrical consumption was significantly lower during April, May, and June 1995. Total oil consumption for 1995 was 238,404 gallons, and 70,732 gallons had been used in 1996 as of August. Propane is used for pilot lights for burners throughout the plant and is not a large-consumption fuel for the plant; 4,365 gallons had been used to August 1996.

Field Test

The Yonkers Joint WWTP field test program was conducted from September 23, 1996, to November 3, 1996. Table 2-17 presents a comparison between the unit process loadings and effluent quality during the field test program and the historical values for the facility. The average hydraulic and organic loadings during the field tests were very similar to the historical values.

Field testing consisted of offline sampling, online monitoring, and performance testing of specific equipment and processes. The offline sample results were based on 24-hour composite samples and grab samples taken at various points in the process. The online data consisted of data measured from temporary instruments installed for the test period and the existing online metering equipment at the site. The temporary instruments included DO meters installed in the aeration basin, solids

TABLE 2-17
YONKERS JOINT WWTP – SUMMARY OF UNIT PROCESS LOADING DURING FIELD TEST PROGRAM

Unit Process	Units	Field Test		Historical	
		Average	Maximum	Average	Maximum
Loading					
Hydraulic	mgd	93.9	162	100.8	171
Organic					
BOD_5	mg/L	120	187	121	
	lb/d	88,590	125,229	87,047	124,058
TSS	mg/L	160	364	124	
	lb/d	120,790	230,007	89,744	110,230
Effluent Quality					
BOD_5	mg/L	4.6	11	8.4	
TSS	mg/L	13.9	38	15.3	
Primary Clarifier					
Surface overflow rate	gpd/ft^2	1,581	2,727	1,700	2,880
Aeration Basin					
BOD_5 loading rate	Lb/d 1,000	42	66	53	78
HRT	ft^3	2.9	1.7	2.7	1.8
MLSS concentration	hours	1,342	1,725	2,177	
	mg/L				
Secondary Clarifier					
Solids overflow rate	gdp/ft2	763	1,317	820	1,220
Solids loading rate	lb/h per ft2	0.35	0.57	0.62	0.92
Chlorine Contact Tank					
HRT	min	51	21	48	29
Primary Thickeners					
Solids in	mg/L	2,648			
Solids out	%	7.9		7	
Secondary Thickeners					
Solids in	mg/L	3,819			
Solids out	%	4.3		4.4	
Primary Digesters					
HRT	days	17		12	
Volatiles destroyed	%	77		59	
Secondary Digesters					
HRT	days	27		23	
Volatiles destroyed	%	46		39	

concentration meters in the aeration basin, and solids concentration meters in the final effluent. Plant instruments monitored primary effluent flow, RAS flow, and total air flow. The primary and secondary biogas flow, primary and secondary thickened sludge flow, and centrate recycle were recorded daily. The performance testing consisted of oxygen transfer efficiency testing of the existing aeration equipment, tracer testing of the digesters, and removal efficiency testing of the grit chambers. Table 2-18 presents a summary of the field test activities. Detailed test descriptions and results are presented in the Yonkers Joint WWTP Site Report (CH2M HILL, 1998f).

The major conclusions from the field study period for the Yonkers Joint WWTP were:

- The primary sludge gravity thickeners returned approximately 40 percent of the primary sludge solids back to the plant influent. The third gravity thickener should be brought into service to reduce the thickener loading and improve performance.

- The centrifuge recycle stream returned a significant quantity of solids to the secondary treatment system. The recycled solids had a negative impact on the secondary sludge system.

- The suspended solids in the secondary clarifier were washed out during two storm events over the study period. The final effluent suspended solids washout began at a flow rate of 90 mgd during the first storm and at 120 mgd during the second storm.

- The secondary clarifiers experienced solids washout at a lower than expected hydraulic loading rate, indicating poor hydraulic efficiency. Baffling in the secondary clarifier would likely improve performance.

- The DO concentration in Aeration Tank 6 was greater than the DO concentration in Aeration Tank 3, even though the average air flow was the same. This indicated an uneven flow distribution between the aeration tanks under normal flow conditions.

- The measured standard oxygen transfer efficiency (SOTE: 20°C, 0 mg/L DO) of the existing coarse bubble aeration system is 8 percent.

- The results of the tracer test on the primary digester were inconclusive. However, the measured volatile destruction and biogas production indicated that the digester was performing as expected.

- The tracer test on the secondary digester indicated that the digester was approximately 83 percent efficient.

TABLE 2-18
YONKERS JOINT WWTP - FIELD TEST PROGRAM

Offline Sampling

Sample Location	Frequency	Type of Sample	Analysis
Raw sewage	Daily	24 h	$cBOD_5$, TSS
	2nd day	24 h	NH_3-N, TKN, VSS
	1/week	24 h	COD
Primary effluent	Daily	24 h	$cBOD_5$, TSS
	2nd day	24 h	NH_3-N, TKN, VSS
	1/week	24 h	COD
Secondary effluent	Daily	24 h	$cBOD_5$, TSS
	2nd day	24 h	NH_3-N, NO_3-N, NO_2-N, TKN, VSS
	1/week	24 h	COD
MLSS	Daily	grab/basin	TSS
	2nd day	grab/basin	VSS
RAS	daily	grab	TSS
Sludge			
Primary thick. in	1/wk	grab/comp	TSS
Primary thick. out	2/wk	grab/comp	TS, VS
Primary digester	1/wk	grab	TS, VS
Secondary thick. in	1/wk	grab/comp	TSS
Secondary thick. out	2/wk	grab/comp	TS, VS
Secondary digester	1/wk	grab	TS, VS
Centrifuge in	1/wk	grab/comp	TS, VS
Centrifuge out	daily	grab	TS, VS
Recycle			
Primary thickener	1/wk	comp	$cBOD_5$, NH_3-N, TKN, TSS
Secondary thickener	1/wk	comp	$cBOD_5$, NH_3-N, TKN, TSS
Centrifuge	1/wk	comp	$cBOD_5$, NH_3-N, TKN, TSS
Additional analysis			
Digested sludge		grab	Lithium

Online Monitoring Program

Location	Type	Data
Primary effluent	Flow	1 existing meter - venturi
RAS	Flow	4 existing meters - mag meter
Air	Flow	1 existing meter - venturi
Aeration basin	Dissolved oxygen	8 temporary meters
	Suspended solids (MLSS)	2 temporary meters
Final effluent	Suspended solids	1 temporary meter

Performance Testing

Location	Type	Analysis
Aeration basin	Hydrogen peroxide	Oxygen transfer efficiency
Digester	Tracer test	Mixing
Grit chamber	Settling profile	Removal efficiency

Section 3

WASTEWATER TREATMENT PLANT ENERGY USAGE

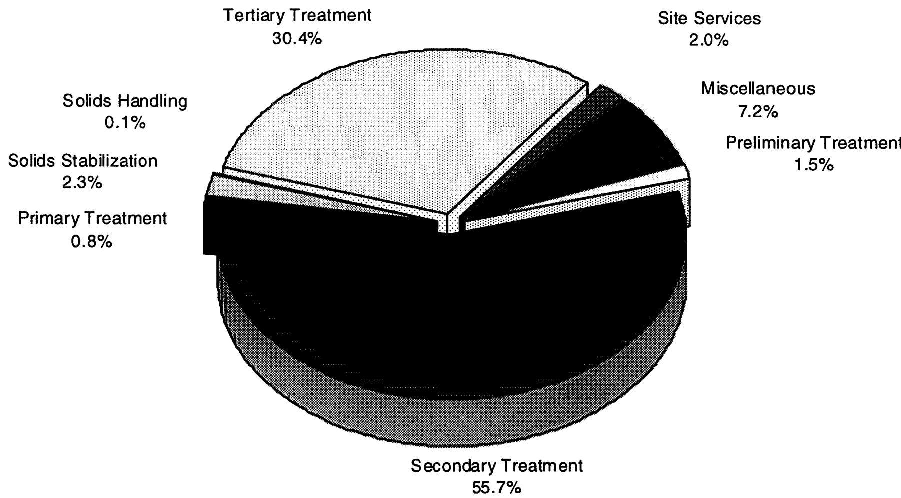
The whole facility energy use was recorded on a 15-minute basis by the local utility at each site. The energy use of the process-related equipment was monitored with temporary submetering equipment installed during the field test period. For motors where the load was not expected to vary significantly during use, time-in-use loggers were installed to record off/on events. Current transducer and voltage potential wires were installed at the breaker panel for motors that would experience significant variation in loading during normal operation. The following sections summarize the electrical use pattern for each site. The detailed electrical submetering results are presented in the individual site report for each facility. Copies of the individual site reports are available through NYSERDA.

ELECTRICAL USAGE PROFILE

Sodus WWTP

A list of the equipment included in the submetering program is presented in Appendix A. The total facility average energy use at the Sodus WWTP was 5,278 kWh per week. The process-related energy consumption measured during the study period was 4,969 kWh per week, or approximately 93 percent of the total energy used. Figure 3-1 presents the average energy use of each of the major unit processes as a percentage of the total energy used and the average weekly energy usage profile for the site. Secondary treatment was the largest electrical energy consumer onsite, accounting for approximately 56 percent of the total energy consumed. The miscellaneous category is the difference between the energy consumption measured by the temporary submetering equipment and the total energy consumption measured by Rochester Gas and Electric, the local utility.

The average weekly electrical energy use profile for the Sodus Village WWTP was fairly consistent throughout the week, with energy use increasing during the midmorning period. While the secondary treatment process was the largest consumer of electrical energy, its load profile was steady. The operation of aeration blowers, trickling filter re-circulation, and aeration pumps did not vary with the load to the plant. It was the fluctuation in the tertiary process that drove the facility demand up each day. This included the secondary effluent pumps, filter blowers, and mudwell mixing pumps.



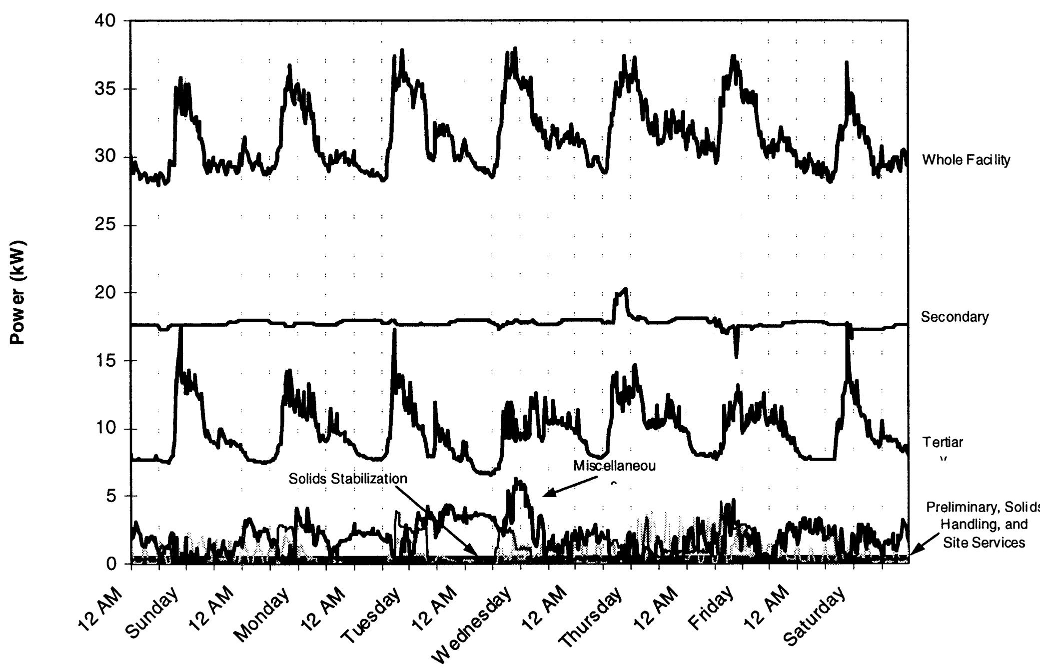


FIGURE 3-1
SODUS WWTP - ENERGY USE OF THE MAJOR UNIT PROCESSES

Goshen WWTP

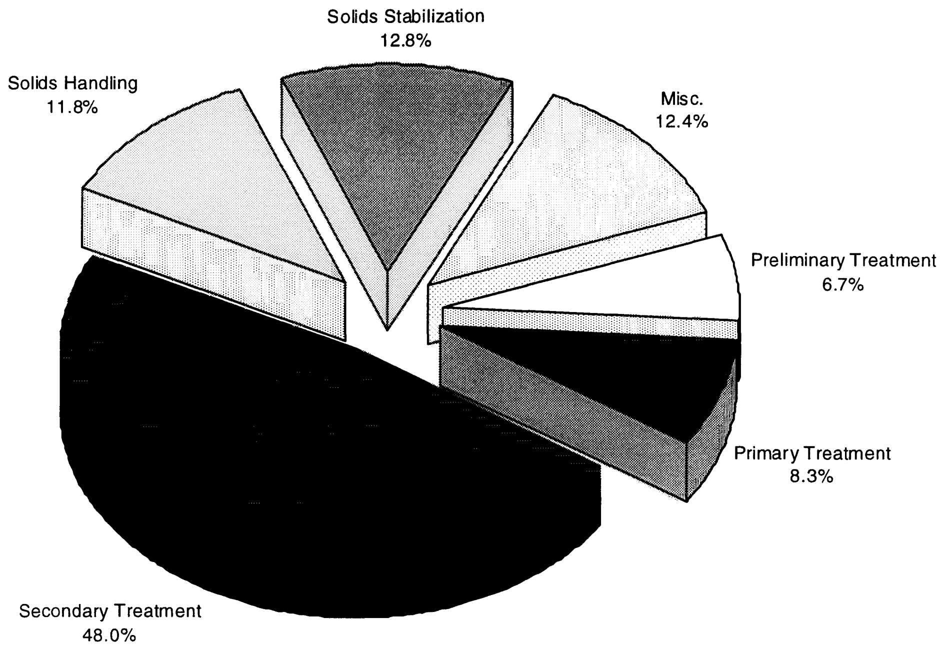
A list of the equipment included in the submetering program is presented in Appendix A. The total facility average energy use for the Goshen WWTP was 5,306 kWh per week. The process-related energy consumption measured during the study period was 4,479 kWh per week or approximately 84 percent of the total energy used. Figure 3-2 presents the average energy use of each major unit process as a percentage of the total energy used and the average weekly energy use profile for the site. Secondary treatment was the largest electrical energy consumer onsite, accounting for approximately 48 percent of the total energy consumed. The miscellaneous category is the difference between the energy consumption measured by the temporary submetering equipment and the total energy consumption measured by Orange and Rockland Utilities, Inc., the local utility.

The average weekly electrical energy use profile for the Goshen WWTP is fairly consistent throughout the week, with energy use increasing during the midmorning period. Secondary treatment was the unit process that drove the facility demand up. This was the result of an increase in flow to the plant during the morning and therefore an increase in pumping requirements. The solids stabilization process actually decreased in midmorning because the digester recirculation pumps were turned off to allow settling and supernating from the digester. This operational practice helped reduce the daily demand for the facility.

Marsh Creek WWTP

A list of the equipment included in the submetering program is presented in Appendix A. The total facility average energy use for the Marsh Creek WWTP was 27,379 kWh per week. The process-related energy consumption measured during the study period was 22,295 kWh per week, or approximately 81 percent of the total energy used. Figure 3-3 presents the average energy use of each of the major unit processes as a percentage of the total energy used and the average weekly energy usage profile for the site. Secondary treatment was the largest electrical energy consumer onsite, accounting for approximately 39 percent of the total energy consumed. The miscellaneous category was the difference between the energy consumption measured by the temporary submetering equipment and the total energy consumption measured by New York State Electric and Gas, the local utility.

The average weekly electrical energy use profile for the Marsh Creek WWTP was fairly consistent throughout the week, with the energy use peaking during the day. The secondary treatment



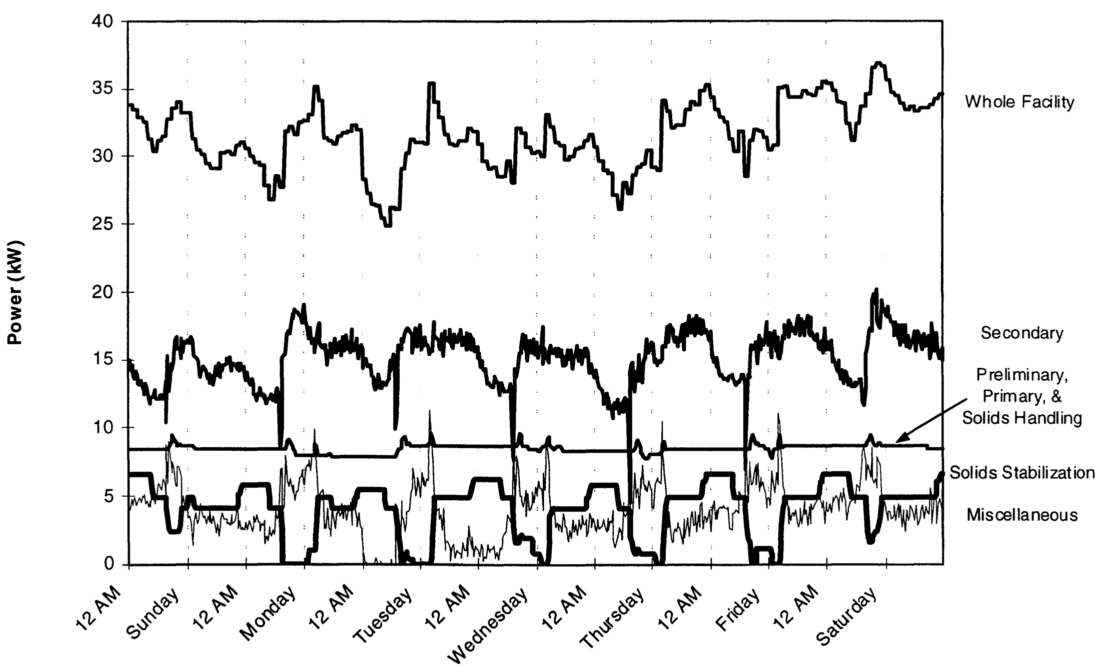
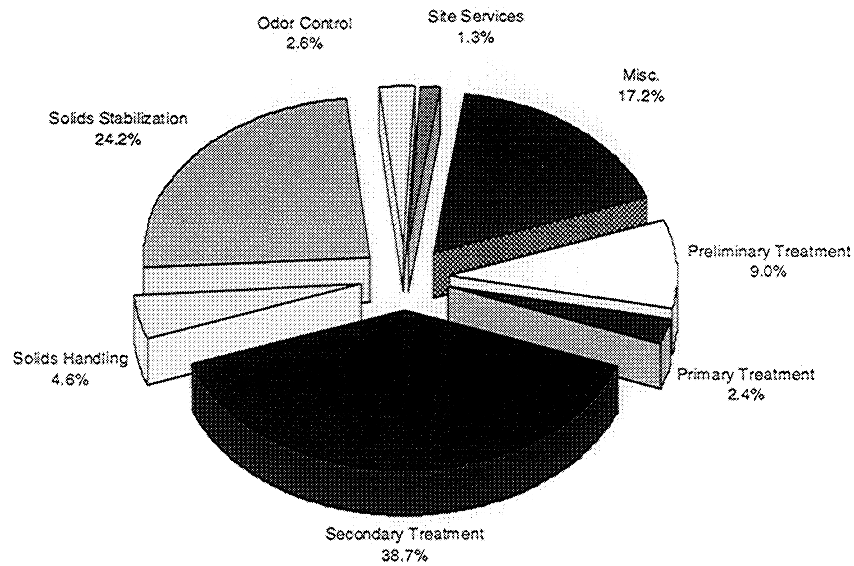


FIGURE 3-2
GOSHEN WWTP - ENERGY USE OF THE MAJOR UNIT PROCESSES



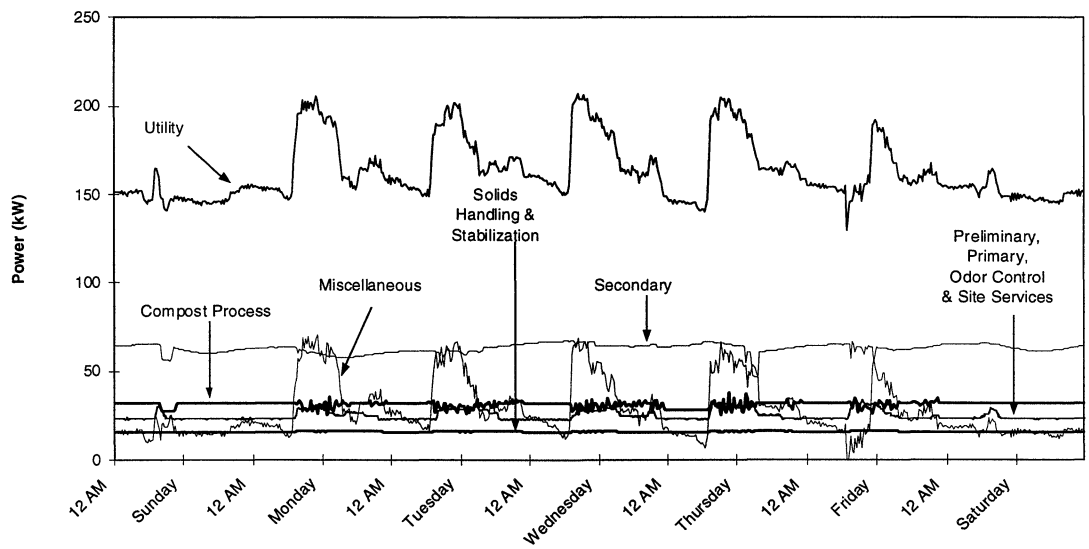


FIGURE 3-3
MARSH CREEK WWTP - ENERGY USE OF THE MAJOR UNIT PROCESSES

process was the largest consumer of electrical energy and its load profile is steady because the Marsh Creek WWTP did not vary the air flow rate based on loading to the plant. Site services and miscellaneous use drove peak demand during the day. The rise in energy demand coincided with the hours when the plant had an operator present.

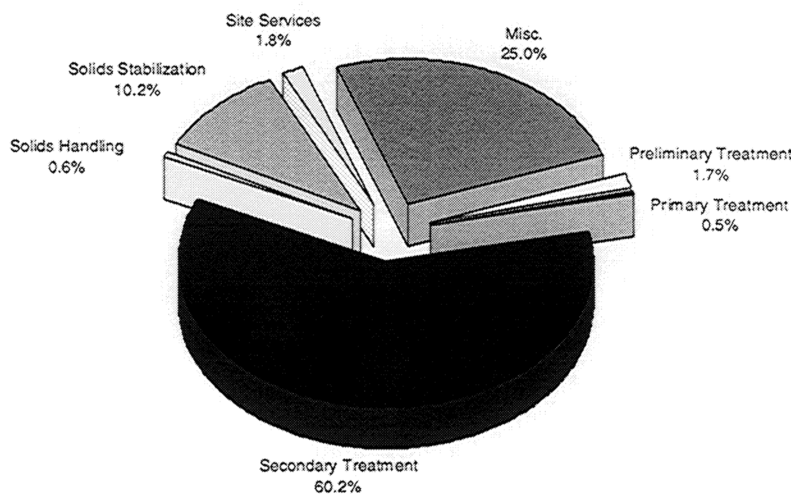
Arlington STP

A list of the equipment included in the submetering program is located in Appendix A. The total facility energy average use for the Arlington STP was 40,090 kWh per week. The process-related energy consumption measured during the study period was 29,369 kWh per week or approximately 73 percent of the total energy used. Figure 3-4 presents the average energy use of each major unit process as a percentage of the total energy used and the average weekly energy use profile for the site. Secondary treatment was the largest electrical energy consumer onsite, accounting for approximately 60 percent of the total energy consumed. The miscellaneous category is the difference between the energy consumption measured by the temporary submetering equipment and total energy consumption measured by Central Hudson Gas and Electric, the local utility.

The average weekly electrical energy use profile for the Arlington STP is fairly consistent throughout the week, with energy use increasing during the evening period. The incineration process drove the facility demand up during the late afternoon and early evening.

Bergen Point WWTP

A list of the equipment included in the submetering program is presented in Appendix A. The whole facility energy use for the Bergen Point WWTP was recorded on a 15-minute basis by Long Island Lighting Company, the local utility. However, inconsistencies were found between the 15-minute data and the monthly utility bills. Therefore, the monthly billing data was used to represent the facility electrical consumption during the study period. The total facility average energy use was 509,521 kWh per week. The process-related energy consumption measured during the study period was 311,825 kWh per week, or approximately 61 percent of the total energy used. Figure 3-5 presents the average energy use of each major unit process as a percentage of the total energy used and the average weekly energy use profile for the site. Secondary treatment was the largest electrical energy consumer onsite, accounting for approximately 33 percent of the total energy consumed. The miscellaneous category is the



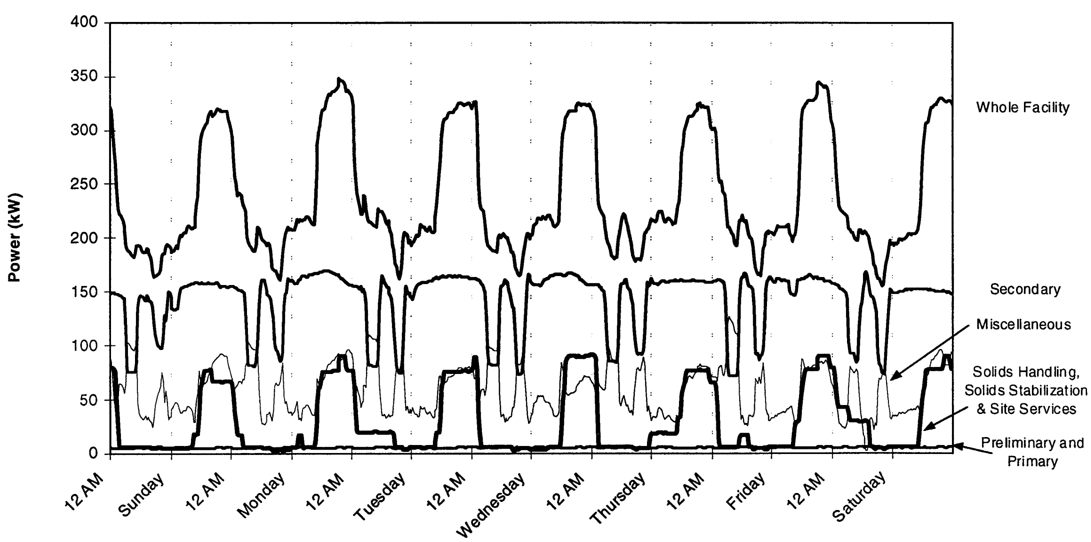
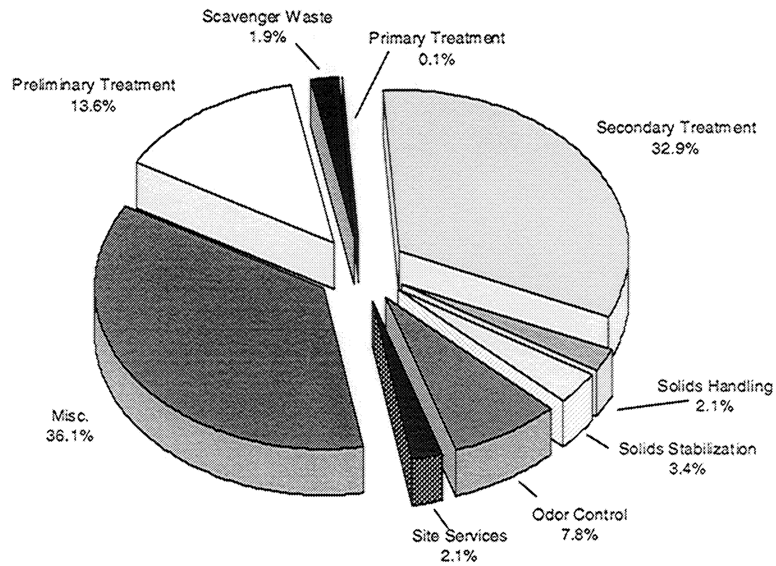


FIGURE 3-4
ARLINGTON STP - ENERGY USE OF THE MAJOR UNIT PROCESSES



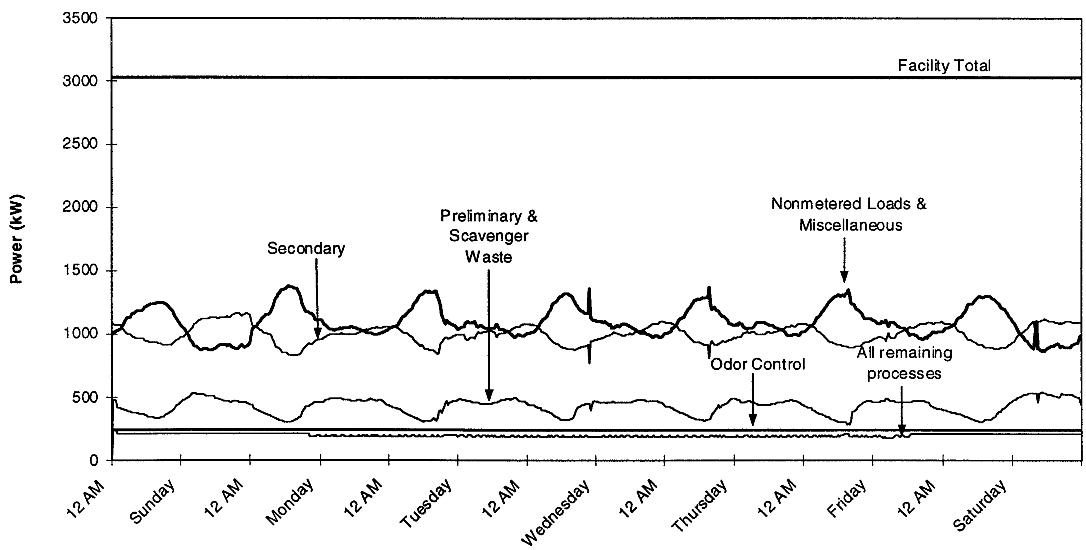


FIGURE 3-5
BERGEN POINT WWTP - ENERGY USE OF THE MAJOR UNIT PROCESSES

difference between the energy consumption measured by the temporary submetering equipment and the monthly billing data provided by Long Island Lighting Company.

The average weekly electrical energy use profile for the Bergen Point WWTP is fairly consistent throughout the week, with energy use increasing during the midmorning period. Raw sewage pumping and secondary treatment were the unit processes that drove the facility demand up. This was the result of an increase in flow to the plant during the morning and therefore an increase in the pumping requirements. The solids handling and stabilization processes exerted a constant energy demand throughout the day.

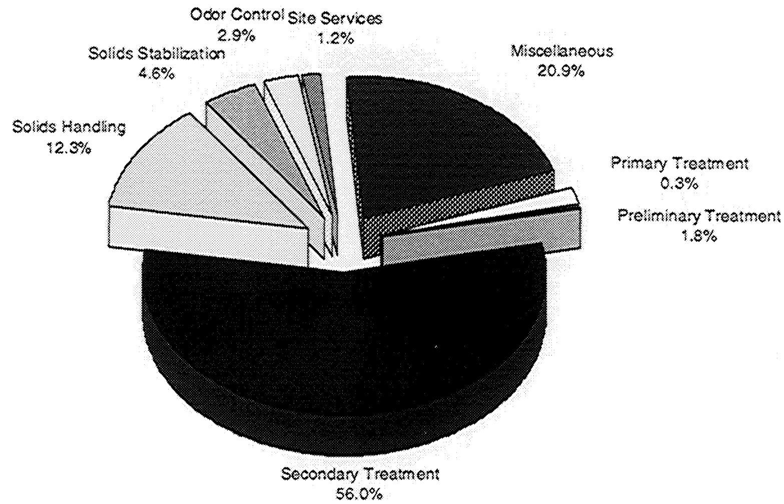
Yonkers Joint WWTP

A list of the equipment included in the submetering program is presented in Appendix A. The total facility average energy use was 653,072 kWh per week. The process-related energy consumption measured during the study period was 509,216 kWh per week or approximately 78 percent of the total energy used. Figure 3-6 presents the average energy use of each of the major unit processes as a percentage of the total energy used and the average weekly energy usage profile for the site. Secondary treatment was the largest electrical energy consumer onsite, accounting for approximately 56 percent of the total energy consumed. The miscellaneous category is the difference between the energy consumption measured by the temporary submetering equipment and the total energy consumption measured by New York Power Authority, the local utility.

The average weekly electrical energy use profile for the Yonkers Joint WWTP is fairly consistent throughout the week, with energy use relatively flat throughout the day. The secondary treatment process was the largest consumer of electrical energy and its load profile is steady because the Yonkers Joint WWTP did not vary the air flow rate based on loading to the plant. The dips observed in the data were the result of maintenance work on one or more of the blowers. The aeration blowers, solids handling operation, and odor control did not vary with the load to the plant.

STANDARDIZED ELECTRICAL USAGE

Table 3-1 presents the electrical energy profile of the unit processes as a function of wastewater treated for the six sites. The Sodus Village WWTP consumed 1,984 kWh per million gallons of wastewater received. The solids handling and disposal processes used approximately 49 kWh per



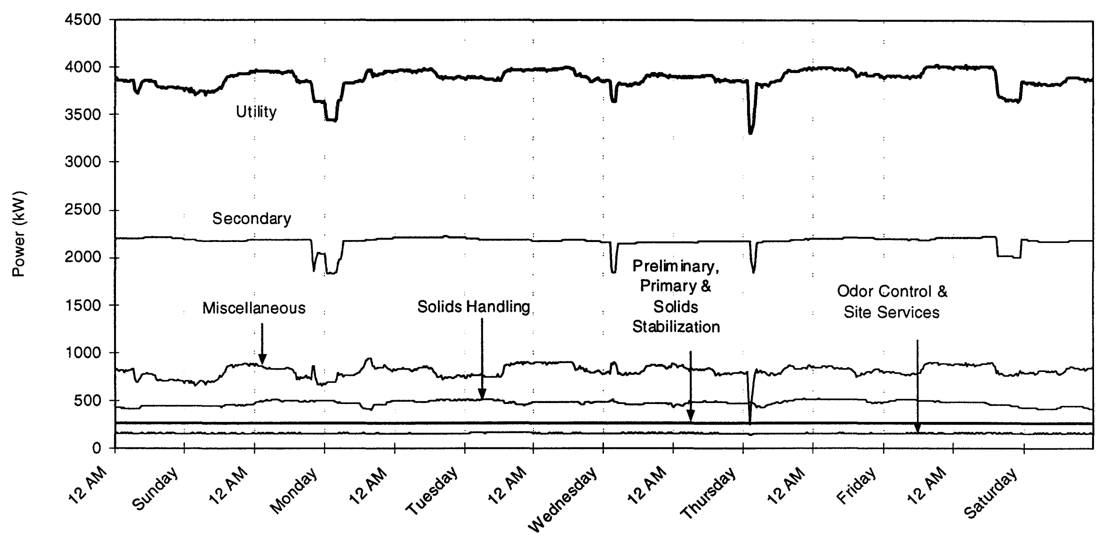


FIGURE 3-6
YONKERS JOINT WWTP - ENERGY USE OF THE MAJOR UNIT PROCESSES

TABLE 3-1
STANDARDIZED ELECTRICAL CONSUMPTION OF THE MAJOR UNIT PROCESSES AT THE SIX WASTEWATER TREATMENT PLANTS

Unit Processes	Sodus (kWh/mg)	Goshen (kWh/mg)	Marsh Creek (kWh/mg)	Arlington (kWh/mg)	Bergen Point (kWh/mg)	Yonkers (kWh/mg)
Preliminary	29.5	32.9	96.7	28.6	364	18.3
Primary	16.4	30.6	25.3	9.0	2.5	3.5
Secondary	1,121	327	417	1,003	922	557
Tertiary	612	NA	NA	NA	NA	NA
Solids handling	20.3	77.2	49.1	9.2	60	122
Solids stabilization	28.3	83.4	54.9	170	95	45
Odor control	NA	NA	28.3	NA	218	28.8
Site and miscellaneous	156.8	102	200	445	1,086	220
Other						
Scavenger					52.5	
Compost			206			
Total	**1,984**	**653**	**1,076**	**1,665**	**2,800**	**994**

million gallons, and the liquid treatment process consumed approximately 1,779 kWh per million gallons. The secondary treatment system (aeration, trickling filter, and secondary clarifier) was the largest consumer, with an average energy demand of 1,121 kWh per million gallons of wastewater treated.

The Village of Goshen WWTP consumed 653 kWh per million gallons of wastewater received. The solids handling and disposal processes used approximately 161 kWh per million gallons, and the liquid treatment process consumed approximately 391 kWh per million gallons. The secondary treatment system (trickling filter and secondary clarifier) was the largest consumer, with an average energy use of 327 kWh per million gallons of wastewater treated. This is low for a secondary treatment plant largely because a conventional trickling filter is a low-energy-consumption treatment process.

The Marsh Creek WWTP consumed 1,078 kWh per million gallons of wastewater received. The solids handling and disposal processes not including composting used approximately 104 kWh per million gallons, and the liquid treatment process consumed approximately 539 kWh per million gallons. The secondary treatment system was the largest consumer, with an average energy demand of 417 kWh per million gallons of wastewater treated. The solids handling processes including composting consumed 310 kWh per million gallons of wastewater treated. The largest single solids-handling electrical energy consumer was the compost facility, with an average consumption of 206 kWh per million gallons of flow.

The Arlington STP consumed 1,665 kWh per million gallons of wastewater received. The solids handling and disposal processes used approximately 179 kWh per million gallons, and the liquid treatment process consumed approximately 1,040 kWh per million gallons. The secondary treatment system was the largest consumer, with an average energy demand of 1,003 kWh per million gallons of wastewater treated.

The Bergen Point WWTP consumed 2,800 kWh per million gallons of wastewater received. The solids handling and disposal processes used approximately 155 kWh per million gallons, and the liquid treatment process consumed approximately 1,341 kWh per million gallons. The site services and miscellaneous uses were the largest consumer, with an average energy demand of 1,086 kWh per million gallons of wastewater treated. The site services portion of the energy demand was very high. Energy conservation opportunities in this area should be investigated. The secondary treatment system was the second largest consumer, with an average energy demand of 922 kWh per million gallons of wastewater treated. The raw sewage pumps consumed 353 kWh per million gallons of wastewater treated.

The Yonkers Joint WWTP consumed 994 kWh per million gallons of wastewater received. The solids handling and disposal processes used approximately 167 kWh per million gallons, and the liquid treatment process consumed approximately 579 kWh per million gallons. The secondary treatment system was the largest consumer, with an average energy demand of 557 kWh per million gallons of wastewater treated.

For the majority of the wastewater treatment plants, the largest electrical consumer was the secondary treatment system. Table 3-2 presents the average electrical consumption of the secondary treatment system in terms of measured average electrical consumption, percentage of total electrical consumption, unit consumption per million gallons of wastewater treated, and unit consumption per pound of oxygen demand (OD) removed.

TABLE 3-2
ELECTRICAL CONSUMPTION OF SECONDARY TREATMENT AT THE SIX WASTEWATER TREATMENT PLANTS

Plant	Measured[a] (kWh/wk)	Percentage[b] (%)	Unit[c] (kWh/mg)	Removal Efficiency[d] (kWh/lb OD removed)
Sodus	2,982	56	1,121	0.773
Goshen	2,659	50	327	0.820
Marsh Creek	10,591	39	417	0.141
Arlington	24,147	60	1,003	1.022
Bergen Point	167,838	33	922	0.599
Yonkers	366,127	56	557	0.539

Notes:
[a] Average weekly electrical consumption measured during study period.
[b] Percentage of total electrical energy used onsite.
[c] Electrical consumption per million gallons of wastewater treated.
[d] Electrical consumption per pound of oxygen demand removed in secondary treatment.

The electrical consumption for secondary treatment varied from 1,121 kWh per million gallons of flow for the Sodus Village WWTP to 327 kWh per million gallons for the Village of Goshen WWTP. The Sodus Village WWTP electrical consumption for secondary treatment was higher than expected based on the measured oxygen transfer efficiency of the aeration equipment. The electrical consumption values per million gallons of wastewater treated for secondary treatment at the Arlington STP and Bergen Point WWTP were almost equivalent, even though the measured oxygen transfer efficiency of the fine-bubble aeration panels at Bergen Point was almost three times greater. However, the organic loading to the secondary treatment system at Bergen Point was significantly higher because of the higher BOD_5 and total Kjeldahl nitrogen (TKN) concentrations in the primary effluent.

The electrical consumption per pound of OD removed in the secondary system is also presented in Table 3-2. It varied from 0.141 kWh/lb OD removed for Marsh Creek to 1.022 kWh/lb OD removed at the Arlington STP. The electrical consumption per pound of OD removed was higher than expected at both the Sodus Village WWTP and the Bergen Point WWTP.

At the Sodus Village WWTP, several inefficiencies were identified in the air handling system including unintentional venting to atmosphere, mixing limitations in the aeration basin, and dissolved oxygen concentrations greater than 2.0 mg/L. Even though the measured oxygen transfer efficiency of the aeration equipment was very good, the potential electrical savings was not achieved. Similarly, at the Bergen Point WWTP, several inefficiencies were identified in the air handling system. The measured "wire to water" efficiency of the aeration blowers was lower than expected, and the capacity of the aeration blowers was greater than required to meet the oxygen demand and mixing limitations in the aeration basins. Even though the measured oxygen transfer efficiency of the aeration equipment was very good, the potential energy savings was not achieved.

Section 4

ENERGY CONSERVATION OPPORTUNITIES

The detailed process and electrical usage information collected during the field work program was used to identify and evaluate ECOs at each site. The ECOs were divided into two categories: operational changes, equipment replacement, and minor capital improvements; and major capital upgrades.

Major capital upgrades include modifications costing more than the average annual energy costs for the facility. By definition, the payback period for major capital upgrades will be long. However, these upgrades may be required or recommended for other than just economic reasons, such as process stability, equipment maintenance, or health and safety concerns.

The estimated capital costs, potential savings, and simple payback periods were determined for the minor capital upgrades. An economic evaluation based on life-cycle costs was developed for the major capital upgrades.

A summary of the ECOs identified at each site and the estimated impact of the recommended ECOs on the available treatment capacity is presented below. More detailed descriptions are located in the individual site reports, which are available from NYSERDA.

SODUS VILLAGE WWTP

Table 4-1 summarizes the ECOs identified for the Sodus Village WWTP. Four minor capital upgrades and two major capital upgrades were identified.

Table 4-2 presents the capital cost estimates, potential savings, and simple payback for the recommended minor capital upgrades. The average simple payback period for the minor capital upgrades is less than two years.

Remove Trickling Filter from Service

The trickling filter's contribution to the overall treatment process is not significant and therefore it is recommended that it be removed from service. The existing aeration basin has sufficient capacity to treat the primary effluent at the current rated capacity of the treatment plant. However, the secondary clarifier is undersized and should be replaced with a larger unit. The

TABLE 4-1 SODUS VILLAGE WWTP – IDENTIFIED ENERGY CONSERVATION OPPORTUNITIES	
Name	**Description**
Operational Changes and Minor Capital Upgrades	
Trickling filter	– Remove trickling filter from service – Savings due to reduced pumping requirements – No impact on available treatment capacity
Aeration blower modifications	– Reduce speed of aeration blowers and increase setting of pressure relief valves – Savings due to reduced volume of air vented to atmosphere through relief valves – No impact on available treatment capacity
Filter blower modifications	– Provide separate airflow control for mudwell mixing and final effluent aeration – Savings due to reduced air requirements for both services – Improved effluent quality due to better control of effluent DO concentrations – No impact on available treatment capacity
Secondary effluent piping modifications	– Replace check valves on the secondary effluent pump discharge lines – Blind flange connection between secondary effluent discharge header and plant recycle line – Savings due to reduced pumping requirements – Increase in available treatment capacity by approximately 25 percent due to reduced recycling of flow through the plant
Major Capital Upgrades	
Nitrification/denitrification	– Install baffle, mixing, and internal recycle to provide an anoxic zone for denitrification in the existing basin – Savings due to reduced oxygen demand associated with denitrification process – Not recommended because the minimum airflow requirements are determined by mixing, not by oxygen demand in the basin
Digester	– Convert existing digester from anaerobic to aerobic service – Increase energy requirements for aeration – Recommended based on life cycle costs – No impact on treatment capacity at site

TABLE 4-2 SODUS VILLAGE WWTP - COSTS OF SMALL CAPITAL AND OPERATIONAL CHANGES (IN PRIORITY ORDER)				
Name	**Capital Cost ($)**	**Energy Savings**		**Simple Payback (Years)**
		kWh/yr	**$/year**	
Aeration blower	0	18,772	1,841	NA
Filter blower	3,000	26,780	1,806	1.7
Secondary effluent piping	1,800	9,880	1,020	1.8
Trickling filter	3,550	14,404	1,741	2.0

WWTP is planning to upgrade the secondary clarifier capacity in 1998. Removing the trickling filter from service would not have an impact on the available treatment capacity at the site.

Aeration Blower Modifications

The WWTP operates two of the aeration blowers at 95 percent of their rated capacity on a continuous basis. The volume of air supplied is approximately twice that required to meet the oxygen demand in the aeration basin. During the field testing it was observed that a significant volume of air was being vented from the air distribution system through the pressure relief valves. It is recommended that the plant operators reduce the blower operating speed, clean the air intake screens, and increase the setting on the pressure relief valves. The operating modifications would not have an impact on the available treatment capacity at the site.

Filter Blower Modifications

One of two blowers in the tertiary filter operates at 95 percent of its rated capacity on a continuous basis. The blower aerates the final effluent and the filter mudwell. There is no control of the air distribution between these services, and the operator reports that it is sometimes difficult to maintain effluent DO concentrations. It is recommended that the plant operators dedicate the second filter blower to aerating the final effluent. The two blowers would be operated and controlled independently, reducing the total volume of air required. This recommendation would not have an impact on the available treatment capacity at the site.

Secondary Effluent Piping Modifications

During the pump efficiency tests it was observed that the backflow prevention valves on the secondary effluent pumps were not operating correctly. A significant volume of secondary effluent was returned to the wet well through the non-duty pumps. It was also observed that the check valve between the common pump discharge header and an out-of-service recirculation line was not installed correctly and approximately 25 percent of the secondary effluent was being pumped to the grit chamber at the head of the plant. These findings indicate the need to replace the pump backflow prevention valves and blind flange the connection between the pump discharge header and the abandoned recirculation line. Preventing recirculation from the secondary effluent wet well to the head of the plant would effectively increase the available treatment capacity by approximately 25 percent.

Other Findings

Of the two major capital upgrades listed in Table 4-1, only one was recommended, upgrading the digester. Upgrading the existing digester was recommended for health and safety reasons. Under current operations the biogas produced in the digester is vented to atmosphere in an uncontrolled manner. Table 4-3 presents an economic evaluation of the two alternative methods of upgrading the existing digester. Converting the existing digester from anaerobic to aerobic service is recommended based on the net annualized costs.

The existing aeration basins have sufficient volume to provide a denitrification zone. Denitrification would require the installation of a baffle to create an anoxic zone, recycle pumps, and mixing equipment. At the Sodus WWTP, the mixing requirement, as opposed to oxygen demand, is the limiting factor for operating the aeration basins. The electrical requirements for the aeration basins after installing denitrification would be higher, therefore, because of the additional energy demand from the recycle pumps and additional mixing. This modification is not recommended.

The Sodus WWTP will, however, be installing a larger secondary clarifier in 1998. Denitrification and floating sludge problems may develop as a result of the increased sludge blanket volume. Providing a denitrification zone in the existing aeration basin is recommended if floating sludge becomes a problem after the clarifier upgrade.

TABLE 4-3
SODUS VILLAGE WWTP – LIFE CYCLE COST ANALYSIS OF MAJOR RECOMMENDED CAPITAL IMPROVEMENT

	Aerobic Digestion	Anaerobic Digestion
Capital cost estimate		
Total capital cost	$115,500	$240,625
Annualized capital cost (6% interest over 20 years)	10,072	20,983
Operation and maintenance costs		
Labor (0.5% of capital cost)	578	1,203
Repairs and maintenance	1,155	2,406
Electrical power	5,460	0
Natural gas	0	0
O&M costs	7,193	3,609
Annual savings		
Electrical power	0	0
Natural gas	(6,406)	(3,200)
Total annual savings	(6,406)	(3,200)
Annualized net costs	10,859	21,392

VILLAGE OF GOSHEN WWTP

Table 4-4 summarizes the ECOs identified for the Village of Goshen WWTP. Two minor capital upgrades and three major capital upgrades were identified.

Table 4-5 presents the capital cost estimates, potential savings, and simple payback periods for the recommended minor capital improvements. The average simple payback for the ECOs identified is less than two years.

Secondary Sludge Pump

The secondary sludge pumps at the Village of Goshen WWTP operate continuously, even though the valve to the sludge well in the secondary clarifiers is closed overnight to ensure raw sewage does not flow back through the pumps. It is recommended that the plant operators replace the backflow prevention valves on the secondary sludge pumps and operate the pumps on a timer. This would allow secondary sludge to be pumped on a periodic basis throughout the day. The secondary sludge would not accumulate in the secondary clarifiers

TABLE 4-4
VILLAGE OF GOSHEN WWTP - IDENTIFIED ENERGY CONSERVATION OPPORTUNITIES

Name	Description
Operational Changes and Minor Capital Upgrades	
Secondary sludge pump	– Provide timers for the secondary sludge pumps – Savings due to reduced pumping – No impact on available treatment capacity
Biogas utilization	– Provide automatic switching between biogas and natural gas – Savings due to reduced propane use – Detailed inspection of gas train required prior to implementation – No impact on available treatment capacity
Major Capital Upgrades	
Upgrade secondary pumps	– Provide variable frequency drives for the existing secondary pumps – Savings due to increased efficiency in pump operation – Improved secondary effluent quality due to reduced shock loading on secondary clarifier
Replace secondary pumps	– Replace existing secondary pumps with an Archimedes' screw type pump – Savings associated with more efficient pump operation – Not recommended based on higher capital costs
Replace biogas train	– Replace existing biogas train – No savings associated with upgrade – Recommended only if required for health and safety reasons based on detailed inspection

TABLE 4-5
VILLAGE OF GOSHEN WWTP - COSTS OF SMALL CAPITAL AND OPERATIONAL CHANGES (IN PRIORITY ORDER)

Name	Capital Cost ($)	Energy Savings		Simple Payback (Years)
		kWh/yr	$/year	
Biogas utilization	9,200	8,372	11,721	0.78
Secondary sludge pump	5,600	30,056	2,235	2.46

*propane - gallons per year

overnight, and the pump operation could be adjusted to maintain an optimum secondary sludge concentration. This recommendation would not have an impact on the available treatment capacity at the site.

Biogas Utilization

The existing anaerobic digester boiler system can be operated using either biogas or propane as a fuel. The switch between biogas and propane is controlled manually based on biogas pressure. The operators switch to propane when the facility is unattended (overnight and on weekends). It is recommended that the plant operators install an automatic control valve so that the biogas generated would be fully utilized. This recommendation would not have an impact on the available treatment capacity at the site.

Other Findings

Of the three identified major capital ECOs, only one, to upgrade the secondary pumps by installing variable frequency drives (VFDs), is unconditionally recommended. The pumps are currently operated off/on, based on liquid level in the trickling filter sump. The continuous short- term hydraulic perturbations have a significant negative impact on the secondary effluent quality. The modification would not increase the hydraulic capacity of the secondary treatment system. However, it would prolong the expected life span of the treatment wetlands by improving the secondary clarifier effluent quality and therefore reducing the organic loading during dry-weather flow conditions. The other identified ECO with regard to the secondary pumps — replacing them with an Archimedes' screw-type pump — is not recommended. Table 4-6 presents an economic comparison of the two alternative ECOs. Installing VFDs is recommended based on this comparison. The third major capital ECO, replacing the biogas train, is only recommended if required for health and safety reasons. Detailed costs for this upgrade have not been worked out, but the capital cost is preliminarily estimated at $82,000.

MARSH CREEK WWTP

The Marsh Creek WWTP provides good to excellent treatment with few areas for improvement in operational efficiency. Table 4-7 summarizes the ECOs identified. Several of these recommendations have been or will be implemented as part of a larger project directed at providing additional capacity to treat wastewater from a local industrial source. The identified ECOs are discussed below.

TABLE 4-6 VILLAGE OF GOSHEN WWTP - LIFE CYCLE COST ANALYSIS OF MAJOR CAPITAL IMPROVEMENTS		
	VFD	**Archimedes' Screw**
Capital cost estimate		
Total capital cost	$41,250	$207,694
Annualized capital cost (6% interest over 20 years)	3,592	18,111
Operation and maintenance costs		
Labor (1 day/month)	4,800*	4,800
Repairs and maintenance	1,200*	600
Electrical power	4,090	5,500
O&M costs	10,090	10,900
Annual savings		
Electrical power	7,540	7,540
Other		
Total annual savings	7,540	7,540
Annualized net costs	6,142	21,471

*includes O&M costs for existing pumps

TABLE 4-7
MARSH CREEK WWTP - IDENTIFIED ENERGY CONSERVATION OPPORTUNITIES

Name	Description
Automatic DO control	– Provide automatic DO control system to control blower operation based on DO measured in aeration basin – Minimal energy savings because of low DO in aeration under current loading and operational conditions – Not recommended
Load levelling	– Provide storage and transfer facilities for hauled wastes so that the high-strength wastes can be fed through the system during low loading periods – No energy savings associated with upgrade – Increase in available treatment capacity during peak demand periods – Will be implemented as part of larger project to provide industrial wastewater storage and pretreatment onsite
Digester performance	– Upgrade mixing system in digester to improve efficiency – Recommended if plans to accept additional sludge for treatment are implemented – Increase in solids treatment capacity
Biogas utilization	– Modify administrative building heating system to utilize hot water from existing boiler – Energy savings associated with reduced propane for heating – No impact on available treatment capacity

Automatic DO Control. The potential energy savings associated with the installation of an automatic aeration control system based on DO concentration in the aeration basin were investigated. The results of the analysis indicated that there were little or no savings associated with providing online DO control. The average DO in the aeration basin is less than 0.5 mg/L for significant periods during the day. There are potential savings at night and on weekends. However, the savings are minimal (less than 100 kWh/day) and difficult to realize because of the minimum air flow required to maintain pressure in the fine-bubble aeration panels. Therefore, providing automatic aeration control based on DO measurement is not recommended.

Organic Load Levelling (Equalization). The Marsh Creek WWTP receives a significant portion of its organic loading from industrial sources, including food processing and hauled leachate from the local landfill. The intent is to transfer leachate from a storage tank on a continuous basis 24 hours per day. However, the leachate feed line is a gravity system that is susceptible to plugging problems and operators routinely open the throttling valve on the line to flush the system. This results in a significant increase in organic loading to the WWTP, which usually occurs in the midmorning when domestic loading is also at the diurnal peak.

Load levelling would reduce the peak organic loading to the plant by feeding the leachate into the wastewater during the night when the domestic load is low. The primary benefits of load levelling would be to reduce peak oxygen demand in the aeration basin, to reduce shock loading and process upset potential for the biological system, and to increase the treatment capacity available during peak periods.

Load levelling will be incorporated into a proposed industrial wastewater storage and pretreatment facility constructed at the Marsh Creek site. The new facility will provide load levelling for high-strength wastewater received onsite.

Digester Performance. The lithium tracer test performed on the primary digester indicated that approximately 79 percent of the available volume was utilized. The efficiency of the primary digester could be improved by upgrading the digester mixing system. Under current loading conditions, improving the efficiency of the existing digesters is not a critical requirement. The Marsh Creek WWTP is considering using the surplus digester capacity to import sludge from other facilities for treatment onsite. The imported sludge is a potential income source for the facility, and the additional biogas generated could be used to supplement the building heat during the winter months. Under these loading conditions, digester efficiency is of greater concern. Marsh Creek WWTP is upgrading its digester mixing system over the period 1997–1998.

Biogas Utilization. Under current loading conditions the biogas produced at the Marsh Creek WWTP is required to heat the digester. The existing boiler system is sized appropriately for this task and the majority of the biogas produced is being utilized. However, if the Marsh Creek WWTP receives additional sludge from other sources for digestion onsite, the additional biogas generated can be used for other purposes.

The administrative building heating system could be modified to use hot water from the existing boiler in the makeup air unit to supplement the propane used for heating. Work would include provision of new heating coils with thermal valves in the supply air ducting, hot water piping from the boiler room to the administrative building, and minor modifications to the boiler room piping and air supply units. The estimated capital cost for this work is $44,600. The estimated savings are $4,260 per year. The simple payback time for these modifications is approximately 10.5 years.

ARLINGTON STP

Table 4-8 summarizes the ECOs identified for the Arlington STP. Nine minor capital upgrades or operational changes and two major capital upgrades were identified.

Table 4-9 presents the capital cost estimate, potential savings, and simple payback for the eight recommended minor capital improvements.

Modifications to Aeration Basin

The Arlington STP blowers do not have sufficient capacity to meet the organic and nitrogenous oxygen demand in the aeration basin. This results in several operating problems, including excessive filamentous growth, foaming, and sludge bulking. Chlorination of the RAS line is used to control the sludge bulking. The study evaluated the potential to install an anoxic selector and/or anoxic zone for single sludge nitrification/denitrification at the head of the existing aeration basin. Providing an anoxic selector at the influent end of the aeration basin will not have a significant impact on the available treatment capacity at the site. However, it will reduce filamentous problems, improve effluent quality, and reduce the need for chlorination of the RAS.

Providing an anoxic zone for single sludge nitrification/denitrification will increase the available treatment capacity of the aeration system during the summer months when the secondary system is nitrifying. The

TABLE 4-8 ARLINGTON STP - IDENTIFIED ENERGY CONSERVATION OPPORTUNITIES	
Name	**Description**
Operational Changes and Minor Capital Upgrades	
Aeration basin anoxic selector	– Provide an anoxic selector at the upstream end of the aeration basin – Recommended to improve sludge settleability by controlling filamentous growth – Improved sludge settleability and therefore effluent quality
Aeration basin denitrification	– Provide an anoxic zone for denitrification – Savings associated with oxygen credit in aeration basin due to the denitrification process – Improved sludge settleability and therefore effluent quality
Online control of chlorination	– Provide oxidation/reduction potential (ORP) control for existing chlorination system – Not recommended because of current low chlorine usage and therefore minimal savings – No impact on available treatment capacity
RAS pumps drive replacement	– Provide VSD control for existing RAS pumps – Savings due to reduced energy required to pump against a high head – No impact on available treatment capacity
Aeration blower 3	– Replace existing split ring drive system with a single-speed belt drive – Savings due to improved drive efficiency – No impact on available treatment capacity
Dewatered sludge hopper	– Provide interim storage between belt press and incinerator – Savings due to increased loading rate to the incinerator and therefore reduced excess air – Increase in available solids treatment capacity
Incinerator refractory arch	– Brick-in the incinerator refractory arch to reduce the optimum feed rate for the incinerator – Savings due to reduced excess air in the incinerator – Decrease in available solids treatment capacity
Fine-bubble aeration	– Replace existing coarse-bubble aeration with fine-bubble diffusers – Savings due to increased oxygen transfer efficiency – Increase in available treatment capacity in aeration basin
Motor replacement	– Upgrade existing motors to high-efficiency for the aeration blowers and RAS pumps – Savings due to improved efficiency – No impact on treatment capacity

Table 4-8 (cont'd) Arlington STP - Identified Energy Conservation Opportunities	
Name	**Description**
	Major Capital Upgrades
Dewatered sludge receiving station	– Accept dewatered sludge from other facilities for incineration at Arlington STP – Potential income generation – Full utilization of existing capacity
Liquid sludge receiving station	– Accept liquid sludge from other facilities for incineration at Arlington STP – Potential income generation – Full utilization of existing capacity

Table 4-9
Arlington STP - Costs of Small Capital and Operational Changes (in priority order)

Name	Capital Cost ($)	Energy Savings		Simple Payback (Years)
		kWh/yr	$/year	
RAS pump drive replacement (each)	7,756	162,760	7,585	1.02
Blower 3 drive replacement	3,000	39,520	1,841	1.63
Motor replacement (4 motors)	12,485	55,640	2,593	4.8
Fine-bubble aeration	231,000	244,296	23,000	10.0
Dewatered sludge hopper	198,000	8,580*	12,600	15.7
Modify incinerator	100,000	8,580*	6,090	16.4
Aeration basin anoxic selector	150,150		NA	NA
Aeration basin nitrification/ denitrification	300,300	277,680	12,900	23

*oil gallons/year

current oxygen demand due to nitrification is 1,445 lbs/day. If denitrification were provided in the aeration basin, the current oxygen credit for nitrificationdenitrification would be 635 lbs/day based on 90 percent ammonia removal through nitrificationdenitrification in a single-sludge biological treatment system. This provides a potential energy savings of 631,800 kWh per year. However, the energy savings associated with denitrification are offset by the energy required for additional mixing and mixed liquor pumping.

Under current loading conditions, providing nitrification/denitrification represents approximately 0.75 mgd of additional flow capacity during the summer months. The volume of waste activated sludge produced will decrease by approximately 20 percent.

RAS Pump Drive Replacement

The RAS flow rate is controlled by throttling the RAS discharge line to each aeration basin. It is recommended that the plant install VSDs on the existing RAS pumps to improve the efficiency of this operation. This recommendation would not have an impact on the available treatment capacity at the site.

Aeration Blower 3

The split-ring drive mechanism for Aeration Blower 3 was very inefficient at the lower speeds. It is recommended that the plant operators replace the split-ring drive with a single-speed drive system to operate this blower. Aeration Blowers 1 and 2 have variable-speed drive systems, which can be used to modify the total air flow to the aeration basin. This recommendation would not have an impact on the available treatment capacity at the site.

Dewatered Sludge Hopper

The solids loading rate to the fluidized bed incinerator at the Arlington STP is determined by the optimum loading rate to the belt filter press. The incinerator is operating at approximately 200 percent excess oxygen. It is recommended that the plant provide intermediate storage of the dewatered sludge so that the incinerator could be operated at a higher loading rate. This recommendation would increase the throughput capacity of the incineration process by approximately 100 percent.

Incinerator Refractory Arch

An alternative approach to optimizing the incineration process would be to reduce the capacity of the incinerator by bricking in the refractory arch. The optimum throughput capacity of the incinerator and belt press would then be similar. This method was not recommended because it would reduce the available solids stabilization capacity by approximately 50 percent.

Fine-bubble Aeration

The measured oxygen transfer efficiency (OTE) of the aeration equipment at the Arlington STP was 6 percent. The aeration equipment is not able to meet the oxygen demand during the summer months under current loading conditions. The study recommended upgrading to a fine-bubble aeration system. Based on an estimated OTE of 8 percent (a conservative estimate), the available treatment capacity of the secondary system would increase by approximately 980 lbs/day of oxygen demand. Under current loading conditions, this would represent approximately 1.8 mgd in the winter and 0.8 mgd in the summer months.

Motor Replacement

Several of the motors at the Arlington STP should be replaced with premium-efficiency units. This recommendation would not have an impact on the available treatment capacity at the site.

Other Findings

The Arlington STP has significant excess capacity in the existing sludge incineration process. The two identified major capital upgrades are alternative methods of utilizing the excess capacity in the sludge incinerator system by accepting additional sludge from other facilities in the area. The two alternatives evaluated were constructing a dewatered sludge handling facility beside the existing primary treatment tanks and constructing a liquid sludge handling facility at the entrance to the plant. Table 4-10 presents a comparison of costs of the two alternatives. The costs are based on obtaining sufficient sludge to maintain an 8-hour operation, 7 days per week. The income generation increases if additional sludge is available. The dewatered sludge handling facility is the more cost-effective alternative because both capital costs and operating costs are lower and the income generation potential is higher.

TABLE 4-10 ARLINGTON STP - LIFE CYCLE COST ANALYSIS OF MAJOR CAPITAL IMPROVEMENTS		
	Dewatered Sludge	**Liquid Sludge**
Capital cost estimate		
Total capital cost	$893,764	$1,466,121
Annualized capital cost (6% interest over 20 years)	77,936	127,845
Operation and maintenance costs*		
Labor	145,600	145,600
Repairs and maintenance	4,855	4,425
Electrical power	21,371	28,216
Supplemental fuel	16,700	16,700
Ash disposal	181	181
O&M costs	188,707	195,122
Income generation*	562,598	484,921
Total annual savings	562,598	484,921
Annualized net costs	-295,955	-161,954
Simple payback period (years)	24	5.0
*based on 8-hour operation, 7 days per week		

BERGEN POINT WWTP

Nine minor capital upgrades and one major capital upgrade were identified for the Bergen Point WWTP. Two upgrades were not recommended because the savings are not realizable under current loading conditions and two of the upgrades were not recommended because of excessive capital cost. Table 4-11 summarizes the identified ECOs. Table 4-12 presents the capital cost estimate, potential savings, and simple payback for the recommended minor capital improvements.

Raw Pump Operation

The Bergen Point WWTP raw sewage pumps are equipped with ampli-speed magnetic variable speed drive systems. The efficiency of these drives varies linearly from 0 to approximately 94 percent based on the ratio of pump operating speed to full motor speed. Therefore, operating the pumps at speeds lower than the maximum has a significant impact on the overall efficiency of the pumping process. The study recommended that plant personnel should change the operating strategy of the raw sewage pumps so that the larger pumps

TABLE 4-11 BERGEN POINT WWTP – IDENTIFIED ENERGY CONSERVATION OPPORTUNITIES	
Name	**Description**
Operational Changes and Minor Capital Upgrades	
Raw pump operation	– Modify raw sewage pump control strategy so that the larger pumps operate at maximum speed – Savings due to increased efficiency of drive system at higher speeds – No impact on available treatment capacity
Ampli-speed drive (RAS pumps and raw sewage pumps)	– Replace existing VSD for raw sewage pumps and RAS pumps – Savings due to increased efficiency of drive system – Recommended for RAS pumps – Not recommended for raw sewage pumps because of high capital cost for 4,160-V supply variable speed drives – No impact on available treatment capacity
Aeration blower	– Replace one of the existing aeration blowers with a smaller unit – Savings due to increased efficiency of a blower sized to meet the reduced air requirements – No impact on available treatment capacity
Chemical addition to primary tanks	– Provide chemical addition to improve the performance of the primary clarifiers – Savings due to reduced organic load to secondary system – Not recommended under current loading conditions because savings are not realizable. Airflows to aeration basins are determined by mixing requirements.
Roughing filter	– Convert existing equalization tank to provide a second roughing filter – Savings due to reduced organic load to secondary system – Not recommended under current loading conditions because savings are not realizable. Airflows to aeration basins are determined by mixing requirements.
Incinerator control	– Provide intermediate storage between belt press and incinerator to reduce flareups in incinerator by improved control over sludge feed loading rate – Savings due to reduced maintenance costs, incinerator down time and reduced requirements for sludge haulage – Positive impact on available treatment capacity because of an increased solids stabilization capacity by reduced incinerator down time

TABLE 4-11 (CONT'D) BERGEN POINT WWTP – IDENTIFIED ENERGY CONSERVATION OPPORTUNITIES	
Name	**Description**
Afterburner control	- Provide automatic temperature control of afterburner operation - Savings due to reduced oil consumption in afterburner - No impact on available treatment capacity
Convert to natural gas	- Convert existing incinerator to natural gas operation - Savings due to reduced cost of natural gas on Btu equivalency - Not recommended because of capital cost of conversion - Net reduction in No_x emissions expected
Major Capital Upgrade	
Sludge dewatering	- Replace existing belt presses with centrifuges - Savings due to reduced fuel requirements in incinerator and reduced volume of sludge hauled offsite - Positive impact on available treatment capacity because of an increase in solids dewatering capacity

TABLE 4-12
BERGEN POINT WWTP - COSTS OF RECOMMENDED SMALL CAPITAL AND OPERATIONAL CHANGES (IN PRIORITY ORDER)

Name	Capital Cost ($)	Energy Savings		Simple Payback (Years)
		kWh/yr	$/year	
Raw pump operation	0	717,080	60,900	0
Ampli-speed drive (RAS pump)	116,000	206,544	17,500	5.9
Aeration blower	866,000	2,467,764	201,200	4.3
Incinerator feed control	350,000	NA	NA	NA
Afterburner control	20,000	14,456*	10,000	2.0

*oil - gallons/year

operate at the full motor speed throughout the day. This recommendation would not have an impact on the available treatment capacity at the site.

Replace Ampli-speed Drive

The raw sewage and return activated sludge pumps are equipped with ampli-speed magnetic variable speed drive systems. The efficiency of these drives varies linearly from 0 to approximately 94 percent based on the ratio of pump operating speed to full motor speed. The return activated sludge pumps operate at between 46 to 57 percent of the full motor speed. It is recommended that the plant operators replace the ampli-speed drives on the return activated sludge pumps. It is recommended that would not have an impact on the available treatment capacity at the site.

Replace Aeration Blower

The air requirements at the Bergen Point WWTP have decreased as a result of the recent upgrade from coarse- to fine-bubble aeration. The WWTP is operating with a single blower in service with the inlet guide vane at its lowest setting. The plant operators should replace one of the three blowers with a smaller unit to increase the efficiency of the aeration process. This recommendation would not have an impact on the available treatment capacity at the site. Two of three blowers would remain at their current capacity.

Incinerator Control

The Bergen Point WWTP multiple hearth incinerators experience short-term sudden increases in temperature (flareups) on a regular basis, likely due to sudden changes in sludge feed rate. The flareups contribute to clinker formation in the incinerator body, which results in increased operations and maintenance costs and incinerator down time. The plant should provide intermediate storage and sludge pumping to improve control over the sludge feed rate. This recommendation would increase the solids stabilization capacity by reducing the incinerator down time. Under current operating conditions, only one of the Bergen Point incinerators is in service and the other incinerator is out of service approximately 25 to 30 percent of the time. Reducing the flareups will likely reduce the down time to less than 10 percent and allow the facility to operate both incinerators. This would result in an increase in average capacity from 90 to 200 tons/day for the incineration process.

Incinerator Afterburner Control

Approximately 37 percent of the oil consumed during incineration is used in the afterburner, and there is no control over the afterburner operation. The plant operators should install an automatic temperature control that would allow the afterburner operation to be adjusted to maintain the minimum temperature to meet emissions requirements. This recommendation would not have an impact on the available treatment capacity at the site.

Other Findings

The existing incinerators at the Bergen Point WWTP represent a significant maintenance problem. Usually only one incinerator is in service and therefore the excess dewatered sludge must be hauled offsite for disposal. Improving the sludge handling process by providing centrifuges would alleviate the situation. The dewatered sludge solids content would be higher using centrifuges, and therefore the disposal costs would be less (incineration oil consumption and sludge haulage costs). This recommendation would result in an increase in the sludge dewatering and disposal capacity at the site. Table 4-13 presents an economic comparison of the recommended upgrade versus the costs for the present system. Upgrading to centrifuge dewatering is the recommended alternative based on the net annualized costs.

TABLE 4-13
BERGEN POINT WWTP - LIFE CYCLE COST ANALYSIS OF MAJOR CAPITAL IMPROVEMENT

	Existing Belt Press	Centrifuges
Capital cost estimate		
Total capital cost	$0	$4,451,700
Annualized capital cost (6% interest over 20 years)	0	388,188
Operation and maintenance costs		
Labor (5 day, 24-hour operation)	36,000	36,000
Repairs and maintenance (2% capital cost)	15,000	89,034
Electrical power	1,410	105,333
O&M costs	52,410	230,367
Annual savings		
Incinerator fuel	0	94,444
Sludge haulage	0	569,126
Total annual savings		663,570
Annualized net costs	52,410	-45,015

YONKERS JOINT WWTP

Five minor capital upgrades were identified for the Yonkers Joint WWTP. These are listed in Table 4-14.

TABLE 4-14 YONKERS JOINT WWTP - IDENTIFIED ENERGY CONSERVATION OPPORTUNITIES	
Name	**Description**
Operational Changes and Minor Capital Upgrades	
Waste gas flare	- Provide automatic ignition system for the waste gas burner - No energy savings associated with upgrade - Recommended for worker health and safety reasons
Automatic DO control	- Modify automatic DO control system to include control of blower based on pressure in discharge header - Provide measurement and control for other air users from the main header including grit removal and aerated channels - Energy savings due to reduced air requirements - No impact on available treatment capacity
Grit chamber air supply	- Provide measurement and control of the air flow to the aerated grit chamber - Energy savings due to reduced air requirements - Improved performance of grit chamber resulting in less grit and inert solids in the primary sludge - Positive impact on available treatment capacity because of an increase in available primary digester capacity
WAS thickening	- Install three gravity belt thickeners on a structural steel platform over existing DAF units - Savings due to reduced energy requirements for the gravity belt thickening process - Capacity limitations in the WAS thickening process have a negative impact on secondary treatment - Positive impact on available treatment capacity because of an increased capacity of secondary sludge handling and stabilization process
Engine blower	- Convert existing engine-driven blowers to dual fuel operation - Savings due to operating the aeration system on biogas - No impact on available treatment capacity

Waste Gas Flare

The waste biogas flare is currently lit by hand. This is a worker health and safety concern for the facility. The plant should install a new biogas flare with a remote ignition system. This recommendation would not have an impact on the available treatment capacity at the site.

Automatic DO System

The Yonkers Joint WWTP has recently upgraded from coarse- to fine-bubble aeration. It is recommended that the plant install an automatic DO control system to control the inlet guide vane position based on pressure in the air distribution header with a most-open-valve control logic. This recommendation would not have an impact on the available treatment capacity at the site.

Grit Chamber Air Supply

The air supply for the aerated grit chamber comes from the aeration blowers. It is recommended that the plant operators install an automatic air flow control valve to maintain a constant air flow to the grit chamber. The air flow rate would be adjusted to the minimum required to prevent organic solids from being removed with the grit, resulting in odor problems onsite. Improving the grit removal efficiency of the aerated grit chamber would have a positive impact on the available treatment capacity of the primary digesters due to reduced grit accumulation. The volume of grit entering the primary digesters in the primary sludge is not measured and is difficult to estimate based on the available information. Therefore it is difficult to quantify the expected increase in available treatment capacity for primary sludge digestion.

WAS Thickening

The WAS sludge thickening process is operating at 100 percent of its capacity. Any equipment problems result in reduced sludge wasting and an accumulation of solids within the secondary system. The study evaluated installing gravity belt thickeners over the existing DAF tanks as a method of increasing the capacity and reliability of the WAS thickening process. This recommendation would double the WAS thickening capacity and therefore would have a positive impact on the available treatment capacity at the site.

Engine Blower

The Yonkers Joint WWTP has three engine-driven aeration blowers to provide air to the facility during power outages. The plant should modify the engine-driven blowers to provide dual-fuel capabilities so that the aeration blowers could be operated on digester biogas produced onsite. This recommendation would not have an impact on the available treatment capacity at the site.

Other Findings

In most cases, the upgrades are recommended to improve process efficiency, reduce existing process bottlenecks, and reduce operating hazards. Table 4-15 presents the capital cost estimate, potential savings, and simple payback for the recommended improvements.

TABLE 4-15
YONKERS JOINT WWTP - COSTS OF ECO (IN PRIORITY ORDER)

Name	Capital Cost ($)	Energy Savings		Simple Payback (Years)
		kWh/yr	$/year	
Waste gas flare	230,000	NA	0	NA
Grit chamber	4,000	NA	0	NA
Engine blowers	1,800,000	17,542,772	721,000	2.5
Automatic DO	3,300,000[a]	9,635,600	396,000[b]	8.3
WAS thickening	1,163,000	816,400	36,700	31.7

Notes:
[a] Includes capital cost to upgrade from coarse-bubble to fine-bubble aeration
[b] Includes savings associated with the upgrade from coarse-bubble to fine-bubble aeration

Section 5
CONCLUSIONS

This project used a combination of process audit, energy audit, and electrical submetering techniques to identify low-capital-cost methods of improving the performance and energy efficiency of six WWTPs in New York State. The plants were selected to provide a representative sample in terms of size, location, and treatment technologies. The plants were operating well within their effluent discharge requirements and provided good to excellent levels of treatment. One of the primary objectives of the study was to determine if this approach is an effective method of identifying ECOs at each site, reducing WWTP operating costs, and improving WWTP performance.

The ECOs identified during the study can be divided into four main categories:

- maintenance and housekeeping items,
- operating and control procedures,
- electrical equipment replacement, and
- capacity-related issues.

Several maintenance and housekeeping ECOS were identified during the study. Common items included inoperable or worn backflow prevention valves on pumps, inappropriate or worn pressure relief valves on aeration blowers, inappropriate valve or gate settings, and worn pumps. The capital costs of replacing these items were usually very small and therefore the payback period for these ECOs was usually less than two years.

The study recommended changes to operating procedures at several of the plants. These ECOs included making changes to pump control strategies, providing measurement and control of miscellaneous air use for common air supply systems, and making changes to solids handling procedures. The capital costs for these recommendations were usually small to moderate and therefore the payback period was usually less than five years.

All of the WWTPs included in the study were more than 20 years old, and substantial technological advances have occurred since the original electrical equipment was installed. At several sites the study recommended replacing older electrical motor and drive systems with more efficient units. The capital costs of these recommendations were moderate and the payback period was usually less than five years.

Excess capacity in one or more unit process was identified as contributing to high energy consumption at many of the sites. Excess blower capacity as a result of upgrading from coarse- to fine-bubble aeration, excess aeration basin volume, and excess solids stabilization capacity were identified. Recommendations included taking basins out of service and downsizing equipment. At one site, intermediate storage for dewatered sludge was recommended to allow the incinerator to be operated at a different loading rate from the BFP. At two sites, the study recommended that the facility use the excess capacity in the solids handling and treatment systems to treat hauled sludge from neighbouring facilities as an income-generating opportunity. The capital costs of these recommendations varied from very small (taking units out of service) to high (constructing hauled sludge receiving facilities). The payback periods varied from less than one year to over 10 years.

The project was conducted in conformance with the general requirements for performing WWTP audits as described in Guidance Manual for Sewage Treatment Plant Liquid Train Process Audits. (CH2M HILL 1995). There are several advantages to this approach:

- Real-time data provides a greater understanding of the dynamic response characteristics of the treatment processes. The impact of energy conservation recommendations on treatment performance can be predicted if the real-time process performance data is available.

- Measured electrical consumption data is required to determine the potential energy savings associated with implementing ECOs. Using a single power draw measurement may over- or underestimate the potential savings.

- Real-time process and performance data is required to evaluate the theoretical versus achievable energy savings associated with implementing ECOs. The data can also indicate methods of increasing the achievable savings.

- Discrepancies or unexpected results in the data provide a good indicator of areas for improved performance that may be overlooked using more traditional approaches.

The audit approach, which consists of a systematic and rigorous methodology for obtaining accurate performance information, is an appropriate tool for identifying ECOs at existing wastewater treatment facilities. Online process data, equipment performance characteristics, and electrical submetering information are required to predict the effect of implementing energy conservation measures. The conceptual approach used for this project was quite simple and useful. Measure what you have, what you are using, and the performance achieved, and then base decisions on improving performance efficiency on the results of the measured data.

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APPENDIX A

Equipment Used in the Submetering Program

TABLE A.1
SODUS VILLAGE WWTP - INVENTORY OF MAJOR PROCESS EQUIPMENT MONITORED DURING THE STUDY PERIOD

Motor		Qty	HP	kW	kWh per Week	EFLH per Week	Manufacturer	Logger
Process	Function							
Preliminary Treatment	Comminutor	1	0.5	0.47	78.4	168.0	NA	E
Primary Treatment	Primary Settling Tank	1	0.25	0.26	43.6	168.0	SynchroGear	E
Secondary Treatment	Aeration Blower #1	1	10.0	6.96	1,135.5	163.2	Lincoln Motors	kWh
	Aeration Blower #2	1	10.0	6.96	1,138.7	163.6	Lincoln Motors	kWh
	Aeration Blower - BYPASS	1	10.0	9.24	5.4	0.6	Baldor Motors	kWh
	Aeration Blower - VSD	1	10.0	0.14	1.4	10.0	Baldor Motors	kWh
	Blower House Main Breaker	1	-	24.91	2,406.8	96.6	NA	kWh
	RAS Pump #1	1	7.5	1.63	254.1	155.9	General Electric Motors	kWh
	Secondary Clarifier	1	0.25	0.26	43.6	168.0	SynchroGear	E
	Aeration Basin Feed Pump #1	1	7.5	1.05	13.8	13.2	NA	kWh
	Aeration Basin Feed Pump #2	1	7.5	2.55	162.9	63.9	NA	kWh
	Trickling Recirc. Pump	1	5.0	0.84	100.8	120.1	NA	kWh
Tertiary Treatment	Digester Supernatant	1	1.0	1.60	48.4	30.3	Reliance Motors	kWh
	Filter Backwash Blower North	1	1.5	2.59	9.5	3.7	NA	TOU
	Filter Backwash Blower South	1	1.5	2.90	90.0	31.0	NA	TOU
	Filter Blower #1	1	7.5	5.70	930.3	163.2	Lincoln Motors	TOU
	Filter Blower #2	1	7.5	6.47	13.8	2.1	Lincoln Motors	TOU
	Mudwell North	1	3.0	8.33	21.3	2.6	NA	TOU
	Mudwell South	1	3.0	8.07	20.7	2.6	NA	TOU
	Secondary Effluent Pump #1	1	7.5	1.99	297.1	149.3	US Motors	TOU
	Secondary Effluent Pump #2	1	7.5	2.05	130.9	63.9	US Motors	TOU
	Secondary Effluent Pump #3	1	7.5	2.12	113.8	53.7	US Motors	TOU
Solids Handling	Sludge Dewatering Screw	1	0.5	0.54	5.7	10.5	NA	TOU
Solids Stabilization	Digester Mixer	1	10.0	3.93	50.7	12.9	NA	TOU
	Digester Recirculation Pump	1	1.5	1.09	24.7	22.7	Marathon Motors	E
Sites Services and Misc.	Site Air Compressor	1	10.0	8.45	108.0	12.8	Marathon Motors	TOU
Total	Total Facility	1	NA	38.00	5,278.0	138.9	NA	kWh

E = Estimated loading and/or usage
TOU = submetered time of use
kWh = submetered electric energy
EFLH = Effective Full Load Hours
NA = Not applicable

TABLE A.2
VILLAGE OF GOSHEN WWTP - INVENTORY OF MAJOR PROCESS EQUIPMENT MONITORED DURING THE STUDY PERIOD

Motor: Process	Motor: Function	Qty	hp	kW	kWh per Week	EFLH per Week	Manufacturer	Logger
Preliminary Treatment	Grinder	1	3	1.75	208.6	119.2	Baldor Motors	TOU
Preliminary Treatment	Grit Remover	1	0.5	0.35	58.8	168.0	NA	E
Primary Treatment	Primary Clarifier	1	0.5	0.61	102.5	168.0	US Electric Motors	E
	Primary Settling Tank #1 - Old	1	0.5	0.44	73.1	168.0	Century Motors	E
	Primary Settling Tank #2 - New	1	0.5	0.44	73.1	168.0	Century Motors	E
Secondary Treatment	Secondary Clarifier Pump A	1	10	7.27	0.1	0.02	Marathon Motors	TOU
	Secondary Clarifier Pump B	1	20	16.23	1,870.5	115.3	Marathon Motors	TOU
	Secondary Clarifier Pump C	1	25	19.56	77.7	4.0	Marathon Motors	TOU
	Secondary Settling Tank #2	1	0.5	0.44	73.9	168.0	General Electric Motors	E
	Trickling Filter Recirculation Pump D	1	7.5	4.66	338.6	72.6	Marathon Motors	TOU/E
	Trickling Filter Recirculation Pump E	1	7.5	4.66	288.5	61.9	Marathon Motors	TOU/E
	Trickling Filter Recirculation Pump F	1	15	9.11	9.4	1.0	Marathon Motors	TOU/E
Solids Handling	Secondary Sludge Pump #1	1	3	1.89	317.3	167.9	General Electric Motors	TOU/E
	Secondary Sludge Pump #2	1	3	1.84	303.0	164.4	General Electric Motors	TOU
	Sludge Transfer Pump	1	3	1.27	6.7	5.3	Baldor Motors	TOU
Solids Stabilization	Digester Heat Exchanger Pump	1	2	1.71	73.6	43.1	General Electric Motors	TOU
	Digester Recirculation Pump #1	1	10	6.44	0.1	0.01	Morris Motors	TOU
	Digester Recirculation Pump #2	1	10	4.84	603.7	124.78	Morris Motors	TOU/E
Total	Total Facility	1	NA	36.89*	5,305.6	143.8	NA	kWh

E = Estimated loading and/or usage   kWh = submetered electric energy   NA = Not applicable
TOU = submetered time of use   EFLH = Effective Full Load Hours
* = Utility's average max kW. Utility's peak max = 48.36 kW

TABLE A.6
YONKERS JOINT WWTP - INVENTORY OF MAJOR PROCESS EQUIPMENT MONITORED DURING THE STUDY PERIOD

Motor		Qty	HP	kW	kWh per Week	EFLH per Week	Manufacturer	Logger
Process	Function							
Preliminary Treatment	Bar Screen Rakes	3	5	2.57	1,295.28	168.0	NA	SPT
	Cross Collector Screw Drive	3	2	0.83	420.00	168.0	GE Motors	SPT
	Degritting Air Compressors	3	50	18.17	9,157.68	168.0	Lincoln Motors	SPT
	Grit Conveyor Belt	1	7.5	1.96	329.28	168.0	NA	SPT
	Grit Incline Screw	1	7.5	5.00	840.00	168.0	Pacemaker	SPT
Primary Treatment	Primary Cross Collector Drives	4	0.75	0.66	445.20	168.0	MAC	SPT
	Primary Longitudinal Collector Drives	10	1.5	1.09	1,831.20	168.0	MAC	SPT
Secondary Treatment	Aeration Blowers	3	1,750	1,075.97	337,361.66	157.0	Siemens Allis	kWh
	RAS Pumps	14	30	21.27	27,254.70	89.7	US Motors	kWh/E[1]
	Secondary Clarifiers	5	1.5	0.91	764.40	168.0	GE Motors	SPT
	Settled Sludge Collector Drives	6	1	0.74	745.92	168.0	GE Motors	SPT
Solids Handling	Cake Feed Pumps	5	15	3.65	919.80	50.4	US Motors	SPT
	Cake Sludge Pumps	4	125	25.65	6,738.77	65.7	Siemens Motors	SPT
	Centrifuges	3	300	90.37	30,831.35	65.9	Reliance Motors	kWh
	Float Collector Drives	6	2	1.06	1,063.44	168.0	Reliance Motors	SPT
	Primary Thickened Sludge Pumps	6	10	2.93	470.74	27.1	Baldor Motors	TOU
	Primary Waste Sludge Pumps	6	30	12.17	9,200.52	126.0	Reliance Motors	SPT
	Recycle Pumps	6	30	25.96	15,265.46	98.0	NA	SPT
	Scum Pumps	2	2	1.42	0.00	0.0	Centrix	SPT
	Secondary Settled Sludge Pumps	6	7.5	5.00	0.00	0.0	Baldor Motors	SPT
	Secondary Sludge Transfer Pumps	12	25	6.77	7,271.34	89.4	Baldor Motors	TOU/E[2]
	Secondary Thickened Sludge Pumps	6	7.5	4.22	750.04	29.6	Baldor Motors	TOU
	Sludge Mixing Pumps	3	40	25.93	4,356.24	56.0	Reliance Motors	SPT
	WAS Pumps	4	20	7.08	3,254.41	69.4	Toshiba Motors	kWh
Solids Stabilization	Boiler Blowers	2	7.5	5.00	840.00	84.0	Baldor Motors	SPT
	Boiler Feed Pumps	2	2	1.42	477.12	168.0	Lincoln Motors	SPT
	Circulation Pumps	12	7.5	3.84	1,936.20	42.0	Toshiba Motors	SPT
	Primary Digester Recirculation Pumps	3	15	4.79	2,011.80	140.0	Toshiba Motors	SPT
	Primary Digester Sludge Transfer Pumps	6	15	5.14	2,591.40	84.0	Reliance Motors	SPT

TABLE A.6
YONKERS JOINT WWTP - INVENTORY OF MAJOR PROCESS EQUIPMENT MONITORED DURING THE STUDY PERIOD

Motor		Qty	HP	kW	kWh per Week	EFLH per Week	Manufacturer	Logger
Process	Function							
	Primary Gas Boosters	4	40	34.53	11,602.08	84.0	US Electric Motors	SPT
	Secondary Gas Boosters	6	100	7.03	7,084.56	21.0	Marathon Motors	SPT
	Sludge Heating Water Pumps	6	10	6.30	3,175.20	84.0	NA	SPT
Odor Control	Carbon Tower	1	30	18.86	3,168.48	168.0	Hartzell	SPT
	Odor Control Air Compressors	3	30	25.10	6,862.84	91.1	Atlas Copco	TOU
	Odor Control Fans	3	60	17.66	8,898.96	168.0	Hartzell	SPT
Site Services	Effluent Recirculation Pumps	2	40	25.77	4,329.36	84.0	Reliance Motors	SPT
	Engine Air Compressors	2	20	0.00	0.00	0.0	Lincoln Motors	SPT
	General Cooling Water Pumps	3	20	3.48	1,169.28	112.0	Marathon Motors	SPT
	Hot Water Circulating Pumps	3	1.5	0.00	0.00	0.0	NA	SPT
	Plant Air Compressors	2	25	13.38	1,729.10	64.6	Allis Chamber	TOU
	Plant Water Pumps	2	7.5	5.00	840.00	84.0	Lincoln Motors	SPT
Total	Total Facility	1	NA	4,192.00	653,071.68	155.79	NA	kWh

NA = Not applicable
kWh = Submetered electric energy
TOU = Submetered time-of-use

SPT = Spot handheld measurement
E = Estimated loading and/or usage
EFLH = Effective Full Load Hours

Notes:
[1]Monitored 6 out of 14 pumps
[2]Monitored 3 out of 12 pumps

TABLE A.4
ARLINGTON STP - INVENTORY OF MAJOR PROCESS EQUIPMENT MONITORED DURING THE STUDY PERIOD

Motor		Qty	hp	kW	kWh per Week	EFLH per Week	Manufacturer	Logger
Process	Function							
Preliminary Treatment	Grinder	1	3	1.52	255.4	168.0	NA	SPT
	Grit Chamber Air Compressor	1	5	2.59	434.2	167.9	NA	TOU
Primary Treatment	Primary Settling Tank Collector #1	1	0.75	0.41	68.9	168.0	Westinghouse	SPT
	Primary Settling Tank Collector #2	1	0.75	0.33	55.4	168.0	Westinghouse	SPT
	Primary Settling Tank Collector #3	1	0.5	0.37	62.2	168.0	Louis Allis Company	SPT
	Primary Sludge Pump #1	1	5	2.52	0.0	0.0	Reliance Motors	TOU
	Primary Sludge Pump #3	1	5	0.97	29.2	30.0	Reliance Motors	TOU
Secondary Treatment	Aeration Blower #1	1	60	53.87	4,670.0	86.7	US Motors	kWh
	Aeration Blower #2	1	60	55.98	4,819.3	86.1	US Motors	kWh
	Aeration Blower #3	1	60	50.22	6,456.8	128.6	Westinghouse	kWh
	RAS Pump #1	1	50	28.29	3,584.9	126.7	Century Motors	kWh
	RAS Pump #2	1	50	27.65	4,178.7	151.1	Ajax Motors	kWh
	Secondary Settling Tank Collector #1	1	0.75	0.37	62.2	168.0	Westinghouse	SPT
	Secondary Settling Tank Collector #2	1	0.75	0.36	60.5	168.0	Westinghouse	SPT
	Secondary Settling Tank Collector #3	1	0.75	0.54	90.7	168.0	Baldor Motors	SPT
	Secondary Settling Tank Collector #4	1	0.75	0.48	80.6	168.0	Westinghouse	SPT
	Secondary Settling Tank Collector #5	1	0.75	0.36	60.5	168.0	Westinghouse	SPT
	Secondary Settling Tank Collector #6	1	0.75	0.49	82.3	168.0	Westinghouse	SPT
Solids Handling	Belt Filter Press	1	3	1.38	67.8	49.1	Baldor Motors	TOU
	Sludge Feed Pump #1	1	5	0.52	1.0	1.9	Reliance Motors	TOU
	Sludge Feed Pump #2	1	5	0.52	22.1	42.8	Reliance Motors	TOU
	Sludge Thickener Pump #1	1	1	0.39	65.5	168.0	US Electric Motors	SPT
	Sludge Thickener Pump #2	1	1	0.39	65.5	168.0	US Electric Motors	SPT
Solids Stabilization	Ash Classifier	1	0.75	0.31	15.9	51.4	Reliance Motors	TOU
	Fluidizing Bed Blower	1	100	76.58	3,630.7	47.4	Reliance Motors	kWh
	Incinerator System Breaker	1	NA	113.76	5,350.1	47.0	NA	kWh
	Injection Purge Air Blower	1	7.5	1.42	69.5	49.0	US Electric Motors	TOU
	Purge Air Blower	1	20	2.46	114.0	46.3	General Electric Motors	TOU
	Scrubber Ash Pump	1	15	3.68	184.6	50.1	US Electric Motors	TOU
	Scrubber Effluent	1	5	1.61	80.7	50.1	US Electric Motors	SPT
Site Services	Make Up Pump	1	7.5	4.58	712.5	155.5	General Electric Motors	TOU

TABLE A.4
ARLINGTON STP - INVENTORY OF MAJOR PROCESS EQUIPMENT MONITORED DURING THE STUDY PERIOD

Motor		Qty	hp	kW	kWh per Week	EFLH per Week	Manufacturer	Logger
Process	Function							
Total	Total Facility	1	NA	389.00	40,090.3	103.1	NA	kWh

kWh = Submetered electric energy
TOU = Submetered time of use
NA = Not applicable
SPT = Spot handheld measurement
EFLH = Effective Full Load Hours

TABLE A.5
BERGEN POINT WWTP - INVENTORY OF MAJOR PROCESS EQUIPMENT MONITORED DURING THE STUDY PERIOD

Motor		Qty	HP	kW	kWh per Week	EFLH per Week	Manufacturer	Logger
Process	**Function**							
Preliminary Treatment	Bar Screens	3	1.5	2.60	145.60	56.0	Allis Chamber	SPT
	Bar Screen Grinders	3	10	26.33	1,474.45	56.0	NA	E
	Grit Conveyor	1	2	0.75	125.44	168.0	NA	SPT
	Grit Cross Collector Tanks	2	5	2.74	230.16	84.0	Westinghouse	SPT
	Raw Influent Pump #1	1	150	101.64	584.43	5.8	GE Motors	kWh
	Raw Influent Pump #2	1	150	188.86	1,382.46	7.3	GE Motors	kWh
	Raw Influent Pump #3	1	300	196.98	8,028.90	40.8	GE Motors	kWh
	Raw Influent Pump #4	1	300	236.04	21,307.33	90.3	GE Motors	kWh
	Raw Influent Pump #5	1	400	292.95	32,898.29	112.3	GE Motors	kWh
Scavenger Waste	Scavenger Waste Sludge Pumps	2	30	10.37	362.73	35.0	GE Motors	TOU
	Scavenger Waste Transfer Pumps	3	50	124.50	3,870.29	31.1	GE Motors	TOU
	Center Mixers	2	10	17.55	2,948.89	168.0	NA	E
	Trickling Filter Effluent Pump	1	7.4	5.52	521.70	94.5	Flight	SPT
	Trickling Filter Influent Pump	1	15	9.59	906.35	94.5	US Electric Motors	SPT
	Trickling Filter Recirculation Pump	1	15	9.59	906.35	94.5	US Electric Motors	SPT
Primary Treatment	Primary Cross Collector Drives	4	0.5	1.08	180.88	168.0	Marathon Motors	SPT
	Primary Longitudinal Drives	4	0.75	1.61	269.92	168.0	Marathon Motors	SPT
Secondary Treatment	Aeration Blowers	2	1,750	2,535.96	158,683.20	62.8	GE Motors	kWh
	Final Tank Collector Drives	6	0.75	2.26	379.68	168.0	GE Motors	SPT
	RAS Pumps	3	125	129.21	8,775.59	47.0	GE Motors	kWh
Solids Handling	Belt Press Drive Motors	4	1.5	4.36	319.37	73.3	NA	TOU
	Belt Press Feed Pumps	4	25	11.21	1,104.60	84.0	Reliance Motors	SPT
	Blended Sludge Transfer Pumps	2	15	19.59	3,290.56	168.0	Reliance Motors	SPT
	Filter Cake Conveyors	2	5	2.43	332.50	133.0	A.O. Smith/Eaton	SPT
	Raw Sludge Pumps	4	30	18.09	759.13	42.0	GE Motors	TOU
	Scum Pumps	2	10	13.17	184.38	14.0	Pacemaker	SPT
	Sludge Well Mixers	2	15	26.02	4,371.91	168.0	NA	E
	Thickened Sludge Pump	1	25	15.89	378.24	23.8	Louis Allis	TOU
	WAS Pumps	2	25	21.25	173.05	8.1	Electric Machinery	TOU

TABLE A.5
BERGEN POINT WWTP - INVENTORY OF MAJOR PROCESS EQUIPMENT MONITORED DURING THE STUDY PERIOD

Motor		Qty	HP	kW	kWh per Week	EFLH per Week	Manufacturer	Logger
Process	**Function**							
Solids Stabilization	Burner Combustion Fans	4	75	61.33	2,158.47	35.2	Allis Chalmers	TOU
	Central Shafts	2	7.5	4.73	397.60	84.0	Eaton	SPT
	Central Shaft Cool Fan	1	15	13.01	2,185.95	168.0	NA	E
	Induced Draft Fans	2	250	83.33	12,546.67	75.3	Reliance Motors	TOU
Odor Control	Odor Control Scrubber Fan #1	1	75	61.53	10,337.60	168.0	Leeson	SPT
	Odor Control Scrubber Fan #2	1	75	44.57	7,487.20	168.0	Leeson	SPT
	Odor Control Scrubber Fan #3	1	20	6.76	1,135.12	168.0	GE Motors	SPT
	Odor Control Scrubber Fan #4	1	100	30.80	5,174.40	168.0	GE Motors	SPT
	Odor Control Scrubber Fan #5	1	100	44.50	7,476.00	168.0	GE Motors	SPT
	Odor Control Scrubber Recirc. Fan #1	1	20	11.27	1,892.80	168.0	US Electric Motors	SPT
	Odor Control Scrubber Recirc. Fan #2	1	20	15.73	2,643.20	168.0	US Electric Motors	SPT
	Odor Control Scrubber Recirc. Fan #3	1	5	1.40	234.64	168.0	US Electric Motors	SPT
	Odor Control Scrubber Recirc. Fan #4	1	15	9.53	1,601.60	168.0	US Electric Motors	SPT
	Odor Control Scrubber Recirc. Fan #5	1	25	9.87	1,657.60	168.0	US Electric Motors	SPT
Site Services	Air Compressors	3	100	77.70	8,701.36	112.0	GE Motors	TOU
	Auxiliary Boiler Feed Water Pumps	3	25	17.60	985.60	56.0	US Electric Motors	SPT
	NaOCl Feed Pumps	7	0.75	4.09	687.12	168.0	Reliance Motors	SPT
	Waste Heat Boiler Feed Water Pumps	3	25	17.00	952.00	56.0	Marathon Motors	SPT
Total	Total Facility	1	NA	3,355.00	509,521.00	151.9	NA	BILL

NA = Not applicable
E = Estimated loading and/or usage
BILL = LILCO monthly bill
SPT = Spot handheld measurement
TOU = Submetered time-of-use
kWh = Submetered electric energy
EFLH = Effective Full Load Hours

TABLE A.3
MARSH CREEK WWTP - INVENTORY OF MAJOR PROCESS EQUIPMENT MONITORED DURING THE STUDY PERIOD

Motor		Qty	HP	kW	kWh per Week	EFLH per Week	Manufacturer	Logger
Process	Function							
Preliminary Treatment	Grinder #1	1	5	1.20	201.6	168.0	Toshiba Premium Motors	SPT
	Grinder #2	1	5	1.36	228.5	168.0	US Motors	SPT
	Grit #1	1	10	6.37	1,070.2	168.0	Baldor Motors	SPT
	Grit #2	1	10	5.70	957.6	168.0	US Motors	SPT
Primary Treatment	Primary Clarifier #1	1	3	2.33	391.4	168.0	US Motors	SPT
	Primary Clarifier #2	1	3	1.50	252.0	168.0	US Motors	SPT
Secondary Treatment	Aeration Blower #1	1	60	32.81	75.5	2.3	Baldor Motors	kWh
	Aeration Blower #2	1	60	35.01	74.9	2.1	Baldor Motors	kWh
	Aeration Blower #3	1	100	59.30	8,487.0	143.1	Baldor Motors	kWh
	Secondary Clarifier #1	1	0.5	0.26	43.7	168.0	US Motors	SPT
	Secondary Clarifier #2	1	0.5	0.26	43.7	168.0	US Motors	SPT
	RAS Pump #1	1	15	5.93	988.3	166.7	Baldor Motors	TOU
	RAS Pump #2	1	15	5.27	878.2	166.6	Baldor Motors	TOU
Solids Handling	Belt Filter Press	1	3	1.00	41.1	41.1	NA	TOU
	Sludge Thickener Pump #1 - East	1	1.5	1.09	183.1	168.0	NA	SPT
	Sludge Thickener Pump #2 - West	1	1.5	1.09	183.1	168.0	NA	SPT
	Sludge Waste Pump #1	1	7.5	2.37	398.2	168.0	Reliance Motors	SPT
	Sludge Waste Pump #2	1	7.5	2.37	398.2	168.0	Reliance Motors	SPT
	WAS Pump #1	1	3	0.27	0.0	0.0	US Motors	TOU
	WAS Pump #2	1	3	0.27	43.0	159.4	US Motors	TOU
Solids Stabilization	Gas Compressor #1	1	7.5	4.15	697.2	168.0	Reliance Motors	SPT
	Gas Compressor #2	1	7.5	4.15	697.2	168.0	Reliance Motors	SPT
Compost Facility	Compost Discharge Gate	1	2	0.47	1.0	2.2	Leeson Motors	TOU
	Compost Exhaust Fan	1	60	20.87	3,469.6	166.3	Toshiba Premium Motors	TOU
	Compost Main Breaker	1	NA	93.38	NA	86.7	NA	kWh
	Compost Mixer	1	30	11.79	101.4	8.6	Baldor Motors	kWh
	Compost Pressurizing Blower #1	1	40	10.70	619.3	57.9	Reliance Motors	TOU
	Compost Pressurizing Blower #2	1	40	11.10	1,050.5	94.6	Reliance Motors	TOU

TABLE A.3
MARSH CREEK WWTP - INVENTORY OF MAJOR PROCESS EQUIPMENT MONITORED DURING THE STUDY PERIOD

Motor		Qty	HP	kW	kWh per Week	EFLH per Week	Manufacturer	Logger
Process	**Function**							
Odor Control	Odor Control Blower #1	1	15	6.82	0.0	0.0	NA	TOU
	Odor Control Blower #2	1	15	6.82	719.4	105.5	NA	TOU
Site Services	Site Air Compressor	1	25	14.73	368.6	25.0	US Motors	TOU
Total	Total Facility	1	NA	206.86	27,378.6	132.4	NA	kWh

NA = Not applicable
TOU = Submetered time-of-use
SPT = Spot handheld measurement
EFLH = Effective Full Load Hours
kWh = Submetered electric energy

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